SIAM Student Chapter @NUS

7th Symposium on Applied and Computational Mathematics

Date & Venue

- 26 February 2018, Monday (Recess Week)
- S17-04-06 (Seminar Room 1), Department of Mathematics

Sponsors

- Society of Industrial and Applied Mathematics (SIAM)
- National University of Singapore (NUS)

Committee Members

- Prof. Weizhu Bao (matbaowz@nus.edu.sg, Faculty Advisor)
- Mr. Hanwen Cui (hanwencui@u.nus.edu, President)
- Ms. Xin Yee Lam (lamxinyee@u.nus.edu, Vice President)
- Ms. Tongyao Pang (pangtongyao@u.nus.edu, Secretary)

Guest Speakers

- Prof. Ne-Te Duane Loh, Department of Physics
- Prof. Edward Teo, Department of Physics
- Dr. Luchan Zhang, Department of Mathematics
- Dr. Quan Zhao, Department of Mathematics
- Mr. Wei Jiang, Risk Management Institute
- Mr. Guodong Xu, Department of Mathematics
- Mr. Yancheng Yuan, Department of Mathematics

All are welcome!

Society for Industrial and Applied Mathematics

NUS National University of Singapore | Department of Mathematics Faculty of Science

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Programme

Topic Series

- Computational Fluid and Solid Mechanics
- Computational Lens and Bio-imaging Science
- Data Science
- Differential Geometry, Lie Groups, and General Relativity
- Image Processing
- Mathematical Finance

Time	Guest Speaker	Talk Title/Topic Series
08:50-09:00	Opening Remarks	
09:00-10:00	Prof. Edward Teo	Asymptotic Symmetries in General Relativity • Differential Geometry, Lie Groups, and General Relativity
10:00-10:30	Tea Break & Group Photo	
10:30-11:15	Mr. Wei Jiang	A Unified Theory for Diversified Firm's Risk Management • Mathematical Finance
11:15-12:00	Mr. Yancheng Yuan	Clustering: Efficient Algorithm and More • Data Science
12:00-14:00	Buffet Lunch & Noon Break	
14:00-15:00	Prof. Ne-Te Duane Loh	Computational Lenses with X-rays and Electrons • Computational Lens and Bio-imaging Science
15:00-15:45	Mr. Guodong Xu	Removing Partial Out-of-focus Blur from Images • Image Processing
15:45-16:05	Tea Break & Group Photo	
16:05-16:50	Dr. Luchan Zhang	Motion of Grain Boundaries Incorporating Dislocation Structure • Computational Fluid and Solid Mechanics
16:55-17:35	Dr. Quan Zhao	Sharp Interface Models for Solid-state Dewetting and Their Applications • Computational Fluid and Solid Mechanics
17:35-19:00	Pizza Dinner	

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Asymptotic Symmetries in General Relativity

Edward Teo

Abstract

The symmetries of flat Minkowski space-time are well known to be described by the Poincare group, and include translations and rotations. On the other hand, the symmetries of an asymptotically flat space-time are described by the infinite-dimensional Bondi-Matzner-Sachs (BMS) group. This group includes new types of transformations called supertranslations and superrotations, whose physical interpretations remain rather obscure. In this talk, I will introduce the BMS group, and attempt to shed light on the physical meaning of supertranslations. I will describe the geometry of supertranslated Minkowski space-time, and briefly talk about supertranslated black holes.

A Unified Theory for Diversified Firm’s Risk Management

Wei Jiang

Abstract

We propose a tractable dynamic theoretical framework to examine the risk management strategies for a financially constrained diversified firm, coordinating cash inventory, external financing, investment, and dividend payout. The model predicts that a diversified firm’s cash holding could be much lower than a specified firm’s, consistent with the empirical findings in Duchin (2010). The existence, extent, and the decomposition of financial synergies have been examined, complementing existing literature on this topic. We also develop a regime-switching model to investigate financial synergies in different financing environments. We show that financial synergy in bad state may be significantly higher than that in good state, which is consistent with the empirical findings in Kuppuswamy and Villalonga (2016).

References

Duchin, R. (2010). Cash holdings and corporate diversification. *The Journal of Finance*, *65*(3), 955-992.

Kuppuswamy, V., & Villalonga, B. (2016). Does diversification create value in the presence of external financing constraints? Evidence from the 2007–2009 financial crisis. *Management Science*, *62*(4), 905-923.

Clustering: Efficient Algorithm and More

Yancheng Yuan

Abstract

Clustering may be the most fundamental problem in unsupervised learning which is still active in machine learning research because of its importance in many applications. Popular methods like K-means may suffer from instability, as they are prone to get stuck in its local minima. Recently, the sum-of-norms (SON) model (also known as clustering path), which is a convex relaxation of hierarchical clustering model, has been proposed in Lindsten, F., Ohlsson, H., & Ljung, L. (2011, June) and Hocking, T. D., Joulin, A., Bach, F., & Vert, J. P. (2011, June). Although numerical algorithms like ADMM and AMA are proposed to solve convex clustering model (Chi, E. C., & Lange, K., 2015), it is known to be very challenging to solve large-scale problems. In this paper, we propose a semi-smooth Newton based augmented Lagrangian method for large-scale convex clustering problems. Extensive numerical experiments on both simulated and real data demonstrate that our algorithm is highly efficient and robust for solving large-scale problems. Moreover, the numerical results also show the superior performance and scalability of our algorithm compared to existing first-order methods.

References

Chi, E. C., & Lange, K. (2015). Splitting methods for convex clustering. *Journal of Computational and Graphical Statistics*, *24*(4), 994-1013.

Hocking, T. D., Joulin, A., Bach, F., & Vert, J. P. (2011, June). Clusterpath an algorithm for clustering using convex fusion penalties. In *28th International Conference on Machine Learning* (p. 1).

Lindsten, F., Ohlsson, H., & Ljung, L. (2011, June). Clustering using sum-of-norms regularization: With application to particle filter output computation. In *Statistical Signal Processing Workshop (SSP), 2011 IEEE* (pp. 201-204).

Computational Lenses with X-rays and Electrons

Ne-Te Duane Loh

Abstract

Computational lenses replace the role of physical lenses in an imaging instrument with their computational equivalent. A prime example of this is *phase retrieval*, where the phases associated with the interference pattern due to an illuminated specimen are retrieved using known prior constraints. By retrieving these phases, the specimen's weak phase contrast can be recovered by back-propagating this complex-valued interference pattern to the specimen's focal plane, a function that exceeds the capabilities of current physical lenses.

An application of computational lens that transcends physical lenses is *three-dimensional single particle imaging*. Here, the computational lenses classify an unsorted ensemble of measurements to form the most compatible three-dimensional structure from lower-dimensional projections. Specifically, many random and noisy two-dimensional diffraction patterns of individual biomolecules are recorded at high speed. Thereafter, a Bayesian classification algorithm infers the most likely family of three-dimensional structures that is compatible with these measurements.

In many applications of computational lenses, the basic principles behind either the image formation process or the sample-probe interactions have been known for many decades. However, pursuing their consequences are numerically intensive and requires high-fidelity measurements. In the past two decades, owing to faster computers and brighter X-ray/electron sources, many of these principles can now be effectively translated and integrated directly into imaging instruments as computational lenses.

In this talk, I will outline the basic principles of computational lenses in high resolution X-ray and electron microscopy, show examples of their applications, describe new applications that our group is currently developing, and speculate on the limitations and opportunities in high resolution X-ray and electron microscopy.

Removing Partial Out-of-focus Blur from Images

Guodong Xu

Abstract

Reproducing an all-in-focus image from an image with defocus regions is of practical value to vision systems in many sectors, e.g. digital photography and robotics. It is also a challenging problem as it involves both image segmentation and blind image deblurring. Existing approaches usually take a one-pass approach which separates segmentation and deblurring, and they rely on some parametric form of defocus kernel for deblurring which often is not accurate. This paper proposed an integrated approach to reproduce an all-in-focus image from the input. The proposed approach composed of two novel modules. One is blind defocus blurring method with a rank-based regularization on defocus kernel estimation, and the other is an interaction scheme between defocus region segmentation and defocus kernel estimation. The experiments on real datasets showed the advantages of the proposed method over existing ones.

Motion of Grain Boundaries Incorporating Dislocation Structure

Luchan Zhang

Abstract

We present a continuum model for the dynamics of low angle grain boundaries in two dimensions incorporating both the motion of grain boundaries and the dislocation structure evolution on the grain boundaries. This model is derived from the discrete dislocation dynamics model. The long-range elastic interaction between dislocations is included in the continuum model, which ensures that the dislocation structure on a grain boundary is consistent with the Frank's formula. These evolutions of the grain boundary and its dislocation structure are able to describe both normal motion and tangential translation of the grain boundary and grain rotation due to both coupling and sliding. Since the continuum model is based upon dislocation structure, it naturally accounts for the grain boundary shape change during the motion and rotation of the grain boundary by motion and reaction of the constituent dislocations. Using the derived continuum grain boundary dynamic model, simulations are performed for the dynamics of circular and non-circular two dimensional grain boundaries, and the results are validated by discrete dislocation dynamics simulations.

Sharp Interface Models for Solid-state Dewetting and Their Applications

Quan Zhao

Abstract

Solid-state dewetting is a ubiquitous physical phenomenon occurring in the solid-solid-vapor system. The solid thin film on the substrate is typical unstable and exhibits complex morphological evolutions, including hole formation, edge retraction, rim pinch-off and so on. In this thesis, we develop mathematical models and efficient numerical schemes for simulating the solid-state dewetting, and the problem is approached in both 2D and 3D via the Cahn-Hoffman $\boldsymbol{\xi}$-vector formulation. The sharp interface models are rigorously derived based on the thermodynamic variation, which include the surface diffusion flow and moving contact line. The governing equations for the model belong to fourth order geometric partial differential equations with proper boundary conditions such that the total volume is conserved and total surface energy is dissipative. Besides, a semi-implicit parametric finite element method is proposed for solving the models efficiently. Numerical examples are presented to show consistent morphological evolutions observed in physical experiments.