6th SIAM Student Chapter@NUS Symposium on Applied and Computational Math

- **Date and location:** Feb 21th, 2017; S17-04-06 (Seminar Room 1), Department of Mathematics, Faculty of Science, National University of Singapore.

- **Sponsor:** Society of Industrial and Applied Mathematics (SIAM), National University of Singapore (NUS).

- **Committee:** Bao Weizhu (advisor); Zhao Quan (president); Xu Guodong (vice president); Chen Bo(secretary).

- **Description:** A one-day symposium on industrial and applied mathematics, including 2 plenary talks given by Prof. Tong Xin, Thomson (from Department of Mathematics) and Prof. Alexandre Hoang Thiery(from Department of Statistics and Applied Probability) and 8 talks given by research fellows or PhD students in related areas. Lunch will be provided.

All are welcome!

SIAM
Society for Industrial and Applied Mathematics

NUS
National University of Singapore

Programme

Venue: S17-04-06 (Seminar Room 1)

08:50 - 09:00	**Opening remarks**
09:00 - 09:45	**Plenary talk by Prof. Tong Xin, Thomson**
09:45 - 10:30	**Plenary talk by Prof. Alexandre Hoang Thiery**
10:30 - 11:00	**Tea break & group photo**
11:00 - 11:30	**Talk 3 by Zhao Yufei**
11:30 - 12:00	**Talk 4 by Jiang Wei**
12:00 - 13:30	**Lunch**
13:30 - 14:00	**Talk 5 by Lam Xinyee**
14:00 - 14:30	**Talk 6 by Li Yunzhi**
14:30 - 15:00	**Talk 7 by Tai Cheng**
15:00 - 15:30	**Tea break**
15:30 - 16:00	**Talk 8 by Huang Shan**
16:00 - 16:30	**Talk 9 by Yuan Yancheng**
16:30 - 17:00	**Talk 10 by Ruan Xinran**
17:10-	**Dinner**

Title and abstract

- **Plenary talk 1: 09:00 - 9:45**
  - Speaker: Prof. Tong Xin Thomson
  - Title: Data assimilation in high dimension
  - Abstract: The classical filtering problem concerns of estimating a hidden process through partial sequential observations. Classical filters like the Kalman filter can be derived by the Bayes formula. But they are numerically unfeasible when the underlying dimension reaches several million. The ensemble Kalman filter (EnKF) has been proposed by meteorologists using the idea of Monte Carlo, and finds very good forecast skills. But how does EnKF beats the curse of dimensionality remains an intriguing mystery. The practitioners often attribute this success to an low effective dimension p, of which the formal definition has never been given. The first part of our framework proposes a natural definition for the effective dimension, using the covariance spectrum of an associated Kalman filter. The second component employs the Mahalanobis norm to quantify the EnKF performance, which is intrinsically dissipative for Kalman type of filter updates. This dissipative mechanism is stable enough to wither the noisy perturbation from model or small sampling error. The low effective dimension plays a vital role here, since when $K > Cp$ for a constant C, the sample forecast covariance matrix can concentrate around its expected value, using a new random matrix theory result. Practical covariance inflation and spectral projection are employed to our EnKF. The fact that these augmentations are necessary for our proof, indicates the theoretical significance of these augmentations, while their practical significance has already been observed and well documented.

- **Plenary talk 2: 9:45 - 10:30**
  - Speaker: Prof. Alexandre Hoang Thiery
  - Title: Communication efficient sequential Monte Carlo
  - Abstract: Sequential Monte Carlo methods are a set of genetic-type particle Monte Carlo algorithms; they consists in evolving a set of particles through Markovian mutations and importance sampling selection steps. These methods are widely used in data-assimilation and signal processing; more recently, practitioners have started to exploit them for Bayesian inference in computationally intensive inverse problems. Contrarily to more traditional Markov Chain Monte Carlo (MCMC) methods, it is relatively straightforward to implement SMC algorithms on distributed computing architecture, although very little is known about the asymptotic behavior of SMC in these modern settings. In this talk, I will describe some analysis of the impact of the communication structure of the distributed architecture on the asymptotic stability and statistical fluctuations of the resulting algorithms. I will conclude by showing how to leverage expander graphs (sparse graphs with large absolute spectral gaps) for designing communication efficient parallel SMC methods. This is joint work with my PhD student Deborshee Sen.

- **Talk 3: 11:00 - 11:30**
  - Speaker: Dr. Zhao Yufei

- Title: Discrete frames and tight frames with Gabor structure for sparse image representation
- Abstract: In recent years, sparse approximation has played a fundamental role in many signal processing areas. In this talk, I will present our work about discrete frames and tight frames with Gabor structure, which have many advantages in the sparse representation of images. We construct discrete (tight) frames using Gabor atoms to meet the needs for sparse image modeling. To further introduce the multi-scale property to Gabor systems, we consider the following two approaches. One approach is to define the multi-scale Gabor induced frames by using several constructed frames with windows of various lengths. The other approach is to construct discrete frames with both Gabor and MRA structures. The experiments of image restoration illustrate the efficiency of both systems in sparse image representation.

- **Talk 4: 11:30 - 12:00**
  - Speaker: Jiang Wei
  - Title: A Unified theory for diversified firms: Tobin's q, investment, financing, financial Synergies, and M&A
  - Abstract: We propose a tractable dynamic corporate liquidity management framework to examine strategies of cash holding, corporate investment, external financing, and payout for diversified firms.

- **Talk 5: 13:30 - 14:00**
  - Speaker: Lam Xinyee
  - Title: Fast algorithms for large scale generalized distance weighted discrimination
  - Abstract: High dimension low sample size statistical analysis is important in a wide range of applications. In such situations, the highly appealing discrimination method, support vector machine, can be improved to alleviate data piling at the margin. This leads naturally to the development of distance weighted discrimination (DWD), which can be modeled as a second-order cone programming problem and solved by interior-point methods when the scale (in sample size and feature dimension) of the data is moderate. Here, we design a scalable and robust algorithm for solving large scale generalized DWD problems. Numerical experiments on real data sets from the UCI repository demonstrate that our algorithm is highly efficient in solving large scale problems, and sometimes even more efficient than the highly optimized LIBSVM for solving the corresponding SVM problems.

- **Talk 6: 14:00 - 14:30**
  - Speaker: Dr. Li Yunzhi
  - Title: Numerical study of isotropic-nematic phase transition in hard spherocylidner system using string method
  - Abstract: The dynamics of the complex system is usually driven by some rare but important events. String method is a powerful numerical method in studying the rare events in the complex system. In this talk, I will give a brief review of the string method and its application in the study of the hard spherocylinder system. The hard spherocylinder system is modelled using the molecular dynamics simulations with high complexity. The order-parameter-aided sampling method is introduced to

reduce the complexity of the system and study the isotropic-nematic phase transition in the collective variable space. '

- **Talk 7: 14:30 - 15:00**

  - Speaker: Dr. Tai Cheng
  - Title: Accelerating convolutional neural networks
  - Abstract: Large convolutional neural networks have delivered impressive performance in various computer vision applications. But the memory footprint and computation requirement make it problematic for deploying these models on mobile devices. In this talk, we discuss some tensor decomposition techniques that significantly speedup the training and testing of neural networks.

- **Talk 8: 15:30 - 16:00**

  - Speaker: Huang Shan
  - Title: Life-Cycle consumption, investment, and voluntary retirement with cointegration between the stock and labor markets
  - Abstract: We present an optimal life-cycle consumption, investment, and voluntary retirement model for a borrowing and short sale constrained investor who faces cointegration between the stock and labor markets. With carefully chosen parameters, there exists a target wealth-to-income ratio under which the investor does not participate in the stock market at all, whereas over which the investor increases the proportion of financial wealth invested in the stock market as she accumulates wealth. Contrary to existing retirement studies, retirement flexibility is found to decrease risky asset investment in the presence of cointegration and risk aversion speeds up retirement when labor income risks are uninsurable. The model presented here predicts that early retirement is economically plausible following extraordinary returns in the stock market like those observed in the late 1990s.

- **Talk 9: 16:00 - 16:30**

  - Speaker: Yuan Yancheng
  - Title: SDPNAL+: A′1+′order framework based software for large-scale semi-definite programming problem with user-friendly interface
  - Abstract: SDPNAL+ is a Matlab software package that implements an augmented Lagrangian based method to solve large scale semidefinite programming problems with bound constraints. The implementation was initially based on a majorized semi-smooth Newton-CG augmented Lagrangian method, but we subsequently put it within an inexact symmetric Gauss-Seidel based semi-proximal ADMM/ALM (alternating direction method of multipliers/augmented Lagrangian method) framework for the convenience of deriving simpler stopping conditions. The basic code is written in Matlab, but some subroutines in C language are incorporated via Mex files. We also design a basic interface for users to input their SDP models into the solver. Numerous problems arising from combinatorial optimization and binary integer quadratic programming problems have been tested to evaluate the performance of the solver. Extensive numerical experiments show that the proposed method is quite efficient and robust.

- **Talk 10: 16:30 - 17:00**

- Speaker: Dr. Ruan Xinran
- Title: Mathematical theory and numerical methods for the ground state of Bose-Einstein condensation with higher order interactions
- Abstract: The Gross-Pitaevskii equation (GPE) has been proved to be a success for describing the Bose-Einstein condensate (BEC), where the interaction between particles is approximated by the binary contact interaction. However, this assumption is only true under the low temperature and low density assumptions. In the case of slightly higher particle densities, some correction terms will be included for a better description. And one choice is to include a higher order interaction (HOI) term in the binary interaction part, which will lead to a modified GPE (MGPE). Unlike GPE, the MGPE contains two nonlinear terms and is thus more complicated. In the talk, I will study the ground state of the MGPE analytically, asymptotically and numerically. I will start by showing the existence, uniqueness and non-existence of the ground state, and also the Thomas-Fermi (TF) approximations under two special external potentials, i.e. the harmonic potential and the box potential. A detailed characterisation of the TF approximation is provided, together with some rigorous convergence analysis. Then I will focus on the numerical methods for computing the ground state. Three algorithms will be introduced in details and some numerical results will be provided to show the effects of the two nonlinear terms.