7TH

NUS GRADUATE SYMPOSIUM IN MATHEMATICS

22 April 2019 (Monday)
Department of Mathematics
S17 #04-05 & #04-06

PROGRAMME

Time/Venue	S17-04-06	
08:50 – 09:00	**Opening Address** Prof ZHU Chengbo	
09:00 – 09:45	**Dynamic Games** Prof Sun Yeneng *p2*	
09:45 – 10:15	*Tea break @ Mathematics Department Lounge*	
10:15 – 11:00	**Demystifying tree based and reticulation-visible phylogenetic networks** Prof Zhang Louxin *p2*	
Time/Venue	**S17-04-05**	**S17-04-06**
11:00 – 11:20	Andrew Ernest Hendrickson *p2*	Qian Lilong *p2*
11:20 – 11:40	Chen Rui *p3*	Chng Yuan Zhang Maurice *p3*
11:40 – 12:00	Made Tantrawan *p3*	Qing Huan *p4*
12:00 – 13:00	*Lunch @ Mathematics Department Lounge*	
13:00 – 13:20	Wan Xiaolei *p4*	Zhang Yaquan *p4*
13:20 – 13:40	Wang Chuijia *p5*	Zhang Weiwei *p5*
13:40 – 14:00	Wu Hao *p5*	Jia Yanwei *p5*
	Intermission	
14:40 – 15:00	Wu Chengyuan *p6*	Theo Fanuela Prabowo *p6*
15:00 – 15:30	*Tea break @ Mathematics Department Lounge*	
15:30 – 15:50	Lin Bo (Axxx9457x) *p6*	Nan Yuesong *p6*
15:50 – 16:10	Xi Guojiang *p7*	Yang Liuge *p7*
16:10 – 16:30	Yang Siyao *p7*	Yang Ziyi *p8*
16:30 – 16:50	Chen Enxian *p8*	Zhang Shijun *p8*
16:50 – 17:10	Zhang Teng *p8*	Yuan Yancheng *p9*
17:10 – 17:30	Lin Bo (Axxx9478x) *p9*	Lin Meixia *p9*
17:30 – 17:50		Qian Shuaijie *p10*

(Number in italic denotes page number of abstract)

ABSTRACTS

Prof Sun Yeneng

Dynamic Games

In real life situations, most decisions are made in a dynamic context where multi-period decisions influence the final outcomes. The games of "chess" and "go" are simple examples. In a now classical paper, Zermelo (1913) showed that in any two-person zero-sum game of perfect information in which the players move alternatingly with finitely many choices, either one of the players has a winning strategy, or both players can individually ensure a draw. This lecture will review some basic results in dynamic games and discuss what remains to be done.

Prof Zhang Louxin

Demystifying tree based and reticulation-visible phylogenetic networks

Networks have been used more and more frequently to model horizontal genetic transfers in evolutionary genomics and population genetics in the past two decades. In this talk, I will discuss our recent work on the combinatorial and algorithmic aspects of a couple classes of evolutionary networks.

Andrew Ernest HENDRICKSON

Direct integrals of unitary representations

A standard result in representation theory is that finite-dimensional unitary representations can be written as a direct sum of irreducible representations. Similarly for compact groups, the Peter-Weyl theorem tells us that any unitary representation on a Hilbert space decomposes into an orthogonal direct sum of irreducible representations. For non-compact groups this is not true in general. In the case of a second countable locally compact group, we can at least say that a unitary representation on a separable Hilbert space decomposes instead into what is called a direct integral of unitary representations, which I will describe in this talk.

QIAN Lilong

Decomposition of completely symmetric states

Symmetry is a fundamental milestone of quantum physics and the relation between entanglement is one of the central mysteries of quantum mechanics. In this paper, we consider a subclass of symmetric quantum states in the bipartite system, namely, the completely symmetric states, which is invariant under the index permutation. We investigate the separability of these states. After studying some examples, we conjecture that the completely symmetric state is separable if and only if it is S-separable, i.e., each term in this decomposition is a symmetric pure product state $|x, x\rangle\langle x, x|$. It was proved to be true when the rank does not exceed $\max\{4, N + 1\}$. After studying the properties of these state, we propose a numerical algorithm which is able to detect S-separability. This algorithm is based on the best separable approximation, which furthermore turns out to be applicable to test the separability of quantum states in bosonic system. Besides, we analyze the convergence behaviour of this algorithm. Some numerical examples are tested to show the effectiveness of the algorithm.

CHEN Rui

Local Langlands Correspondence for non-quasi-split unitary groups

Theta correspondence is a useful tool to study representations. In the almost equal rank case, in terms of the LLC, the behaviour of theta correspondence has been well studied by many people. In this talk, I will explain how we 'turn the table around', i.e. we use theta correspondence to construct a LLC for the non-quasi-split unitary groups.

CHNG Yuan Zhang Maurice

Machine Learning with Big Data: Hands-on experience

The author recently took part in the National Data Science Challenge 2019, the largest data science competition in Singapore. In this talk, he will be covering his experience dealing with Big Data and the mathematical models involved. In this classification problem, there are 2 forms of data; images and texts. For the images, an option is to build a custom deep learning model, but this demands extensive computation resources and lots of training data. Instead, the author will introduce transfer learning using Inception V3, the model Google Brain Team has built. For the texts, the author will discuss bi-directional Long short-term memory (LSTM), a recurrent neural network (RNN) architecture using GloVe, a pretrained embeddings. If time permits, a discussion of ensemble method will be discussed to further improve the validation accuracy. The bulk of codes involved Keras with Tensorflow as backend, written using Python.

Made TANTRAWAN

On closures of convex sets in Banach lattices

In this talk, I will explain relations between several types of closures of convex sets in Banach lattices. In particular, I will provide a characterization of when the a-closure of a convex set C in a Banach lattice X is contained in the b-closure of C where (a-closure,b-closure) is any pair from o-closure (order closure), uo-closure (unbounded order closure), $\sigma(X, X_n^{\sim})$ -closure, and $\sigma(X, X_{uo}^{\sim})$ -closure. Relations between the corresponding types of closedness of convex sets will also be discussed.

QING Huan

Community detection by PCC and NPCC

Consider a network where the nodes split into K different communities. The community labels for the nodes are unknown and it is of major interest to estimate them (i.e., community detection). Degree Corrected Stochastic Blockmodel (DCSBM) is a popular network model. How to detect communities with the DCBM is an interesting problem.

We propose two new approaches to community detection which we call principal component clustering (PCC) and normalized principal component clustering (NPCC). PCC is a simple method which does not need any regularization or tuning parameter. NPCC is a refinement of PCC.

The two methods are successfully applied to several real world data sets. Additionally, compared to several well known spectral clustering methods, PCC and NPCC perform satisfactory in numerical simulation both in error rates and computing time.

When dealing with two "weak signal" real world network Simmons and Caltech, by considering one more eigenvectors, we have PCC+ and NPCC+ which are the refinement of PCC and NPCC respectively. NPCC+ performs even better than SCORE+ when dealing with this two "weal signal" networks.

We develop a theoretic framework where we show that under mild conditions, the PCC yields consistent community detection.

WAN Xiaolei

Plancherel decomposition of L^2(U(2)\SO(5))

In this talk, I will give the Plancherel decomposition of L^2(U(2)\SO(5)) which is used the method of Wee Teck and Raul. And explain the relationship of local relative character of representations supported on L^2(U(2)\SO(5)) and L^2(N× T_E\PGSO(4)). Finally, I will introduce the Sakellaridis-Venkatesh Conjecture about Euler factorization about pure spherical character.

ZHANG Yaquan

On the Size Distribution of Market Capitalizations of Cryptocurrencies

The project focuses on the power law distribution observed on the market capitalizations of cryptocurrencies. To explain this observation, we extend the market modelling framework proposed in Malevergne et al. (2013) to incorporate jump diffusion processes. Our results suggest that the power law distribution is a natural consequence of realistic assumptions on the birth, death and dynamics of market capitalizations. Moreover, by studying the convergence rate under the framework, we find the stock markets may have smaller convergence rates than the cryptocurrency market, which explains why the power law is not observed in the stock market.

WANG Chuijia

Distinction problem for Galois symmetric pair

Let E/F be a quadratic extension of p-adic fields, G be a reductive group over F, \pi be an irreducible smooth representation of G(E). We will review some known criterions to detect the distinction property of \pi with respect to some specific character of G(F). We will focus on some examples. (All these contents are not new.)

ZHANG Weiwei

Deep learning algorithm to solve portfolio management problem with proportional transaction costs

Portfolio selection with proportional transaction cost is a singular stochastic control problem that has been widely discussed. We propose a deep learning based numerical scheme to solve transaction cost problems, and compare its effectiveness with a penalty partial differential equation method. We further extend it to multi-asset cases which existing numerical methods cannot be applied to due to the curse of dimensionality. Deep learning algorithm directly approximates the optimal trading strategies by a feedforward neural network at each discrete time. It is observed that deep learning approach can achieve satisfying performance to characterize optimal buy and sell boundaries and thus value function.

WU Hao

Random products of matrices in SL_2(C) and central limit theorem

Let G be the group SL_2(C) of complex 2 by 2 matrices with determinant 1, μ be a non-elementary probability measure on G. We define i.i.d. random matrices g_1,g_2,…,g_n with distribution μ and denote its Lyapunov exponent by γ. Under an exponential moment condition, Le Page proved the sequence of random variables (log||g_n...g_2g_1||-n γ)/√n converges to some normal distribution in 1982. In 2016, Benoist and Quint proved this result under a second moment condition using probability theory, I will introduce the proof using dynamic systems.

JIA Yanwei

Crowd Wisdom and Prediction Markets

Thanks to digital innovation, the concept of crowd wisdom, which aims at gathering information (e.g. Wikipedia) and making a prediction (e.g. using prediction markets) from a group's aggregated inputs, has been widely appreciated. An innovative survey design, based on a Bayesian learning framework, called the Bayesian truth serum (BTS), was proposed previously to reduce the bias in the simple majority rule, so as to get a consistent estimator, by asking additional survey questions. A natural question is whether we can extend the BTS framework to prediction markets (not just polls). To do so, this paper proposes two estimators, one based on a prediction market alone and the other based on both the market and a poll question. We show that both estimators are consistent within the BTS framework, under different sets of regularity conditions. Numerical results are given to illustrate the convergence of different estimators.

This is a joint work with Min Dai and Steven Kou.

WU Chengyuan

Discrete Morse Theory for Weighted Simplicial Complexes

We study Forman's discrete Morse theory in the context of weighted homology. We develop weighted versions of classical theorems in discrete Morse theory. A key difference in the weighted case is that simplicial collapses do not necessarily preserve weighted homology. We work out some sufficient conditions for collapses to preserve weighted homology, as well as study the effect of elementary removals on weighted homology. An application to sequence analysis is included, where we study the weighted ordered complexes of sequences.

(Joint work with Dr. Shiquan Ren, Prof. Jie Wu, and Prof. Kelin Xia)

Theo Fanuela PRABOWO

Nonexistence Results for Strong External Difference Families

Strong External Difference Families (SEDF) were first introduced by Paterson and Stinson in 2016 in order to construct optimal strong algebraic manipulation detection codes. In this talk, we will give basic properties and establish some relations among the parameters of an SEDF. We will then present some nonexistence results.

LIN Bo (Axxx9457x)

Computing Committor Functions for the Study of Rare Events Using Deep Learning with Importance Sampling

The committor function is a central object of study in understanding transitions between metastable states in complex systems. However, computing the committor function for realistic systems at low temperatures is a challenging task, due to the curse of dimensionality and the scarcity of transition data. In this paper, we introduce a computational approach that overcomes these issues and achieves good performance on complex benchmark problems with rough energy landscapes. The new approach combines deep learning, importance sampling and feature engineering techniques. This establishes an alternative practical method for studying rare transition events among metastable states of complex, high dimensional systems.

NAN Yuesong

Deep Learning for Non-blind Deconvolution

Non-blind image deconvolution is an important problem with many applications in vision. Most recent deep learning methods for deconvolution can be viewed as unrolling some iterative schemes of optimization methods. Besides CNN-based image prior, we showed that deliberate treatments on the details of other processes, e.g. inversion process, can also greatly boost the performance of deep learning based methods. Thus, a new deep learning method is presented that introduces a neural network for predicting the inner-loop parameters so as to adaptively regularize the inversion process. Extensive experiments showed that the proposed outperformed existing methods by a significant margin in many settings, including both image deblurring with known noise level and noise-blind deblurring.

XI Guojiang

Deep Molecular Dynamics

Modeling interatomic forces accurately is computationally expensive because of the high dimensionality of the problem. Therefore, molecular dynamics simulation can only be restricted to relatively small systems and time scale. Much effort has been devoted to developing empirical force fields such as Lennard-Jones potential to improve the efficiency. Recently, deep learning is found to be a powerful tool to deal with high dimensional problems. Thus, we established a neural network to learn the interatomic force and implemented molecular dynamics with the learned force.

YANG Liuge

Blind Image Deconvolution

Blind motion deblurring is an important problem that receives enduring attention in last decade.

Based on the observation that a good intermediate estimate of latent image for estimating motion-blur kernel is not necessarily the one closest to latent image, edge selection has proven itself a very powerful technique for achieving state-of-the-art performance in blind deblurring. This paper presented a Bayesian interpretation of edge selection/reweighting in terms of variational Bayes inference, and therefore developed a novel variational expectation maximization (VEM) algorithm with built-in adaptive edge selection for blind deblurring. Together with

a restart strategy for avoiding undesired local convergence, the proposed VEM method not only has a solid mathematical foundation but also noticeably outperformed the state-of-the-art methods on benchmark datasets.

YANG Siyao

Inchworm Monte Carlo Method for Open Quantum Systems

We consider a recently proposed diagrammatic quantum Monte Carlo method — inchworm Monte Carlo method — for the open quantum system, and establish its validity rigorously based on the absolute convergence of the Dyson series. By studying the iterative process of the inchworm method, we introduce an integro-differential equation, which also describes the open quantum system, and agrees well with the inchworm algorithm. This new equation leads to an improvement of the inchworm algorithm by introducing classical deterministic time-integration schemes. The numerical method is verified by applications to the spin-boson model.

Keywords: Inchworm Monte Carlo, open quantum system, spin-boson model

YANG Ziyi

Introducing Res2Net

In this talk, I will introduce the Res2Net building block (proposed by Shang-Hua Gao et al.), which exploits the power of multi-scale features at a granular level by constructing hierarchical residual-like connections within one single residual block.

CHEN Enxian

Some properties of perfect and proper equilibrium

In this paper, we present precise formalizations of the notions of a mixed strategy perfect and proper equilibrium for games with non-atomic measure space of players. We show that (i) the equivalence of behavioral and mixed perfect (resp. proper) equilibrium, and (ii) any mixed perfect (resp. proper) equilibrium has the ex post property.

ZHANG Shijun

Approximation rate of deep relu networks

This paper quantitatively characterizes the approximation power of ReLU feed-forward neural networks (FNNs) for continuous functions. It is shown by construction that ReLU FNNs with width $O(N)$ and depth $O(L)$ can approximate an arbitrary Hőlder continuous function of order α with a Lipschitz constant υ on a d-dimensional cube with a tight approximation rate $5(4\sqrt{d})^{\alpha}\upsilon N^{-2\alpha/d}L^{-2\alpha/d}$. The constructive approximation is a corollary of a more general result for an arbitrary continuous function f in terms of its modulus of continuity $\omega_f(\cdot)$; in particular, the approximation rate of ReLU FNNs with width $O(N)$ and depth $O(L)$ for a general continuous function f is $5\omega_f(4\sqrt{d}N^{-2/d}L^{-2/d})$.

This is a joint project with Shen Zuowei and Yang Haizhao.

ZHANG Teng

Compact Schemes for the nonlinear Klein-Gordon equations

The Klein-Gordon equation is the relativistic version of the Schrodinger equation, which describes the quantized version of the relativistic energy–momentum relation. It is prevalently adopted to model bosons without spin, such as the Higgs boson and the weakly-interacting massive particles (the candidate particles for dark matters). In this talk, I will show the error estimates for some fourth order compact schemes of the nonlinear Klein-Gordon equations in the non-relativistic limit regime, which provide better spatial resolutions than the general second order schemes. Numerical simulation results will also be displayed.

YUAN Yancheng

On the Closed-form Proximal Mapping and Efficient Algorithms for Exclusive Lasso Models

The exclusive lasso regularization based on the ℓ1,2 norm has become popular recently due to its superior performance over the group lasso regularization. Comparing to the group lasso regularization which enforces the competition on variables among different groups and results in inter-group sparsity, the exclusive lasso regularization also enforces the competition within each group and results in intra-group sparsity. In this paper, we derives a closed-form solution for the proximal mapping of ℓ1,2 norm and its generalized Jacobian. Based on the obtained analytical results, we are able to design efficient first and second order algorithms for machine learning models involving the exclusive lasso regularization.

LIN Bo (Axxx9478x)

An efficient and accurate parallel simulator for streamer discharges in three dimensions

An efficient and accurate message passing interface (MPI) based parallel simulator is proposed for streamer discharges in three dimensions using the fluid model, with three features. First, a new second-order semi-implicit scheme is proposed for the temporal discretization, which relaxes the dielectric relaxation time restriction. Moreover, it is second-order accurate in time with solving the Poisson equation only once at each time step. Second, a multigrid preconditioned FGMRES solver is introduced, which dramatically improves the efficiency of elliptic solver. Last but not least, all the methods are implemented using MPI, and the good parallel efficiency of the code is demonstrated. The interaction of two streamers is studied.

LIN Meixia

Efficient sparse semismooth Newton methods for the clustered lasso problems

We focus on solving the clustered lasso problem, which is a least squares problem with the L1-type penalties imposed on both the coefficients and their pairwise differences to learn the group structure of the regression parameters. Here we first reformulate the clustered lasso regularizer as a weighted ordered-lasso regularizer, which is essential in reducing the computational cost from O(n2) to O(nlog (n)). We then propose an inexact semismooth Newton augmented Lagrangian (Ssnal) algorithm to solve the clustered lasso problem or its dual via this equivalent formulation, depending on whether the sample size is larger than the dimension of the features. An essential component of the Ssnal algorithm is the computation of the generalized Jacobian of the proximal mapping of the clustered lasso regularizer. Based on the new formulation, we derive an efficient procedure for its computation. Comprehensive results on the global convergence and local linear convergence of the Ssnal algorithm are established. For the purpose of exposition and comparison, we also summarize/design several first-order methods that can be used to solve the problem under consideration, but with the key improvement from the new formulation of the clustered lasso regularizer. As a demonstration of the applicability of our algorithms, numerical experiments on the clustered lasso problem are performed. The experiments show that the Ssnal algorithm substantially outperforms the best alternative algorithm for the clustered lasso problem.

QIAN Shuaijie

Non-Concave Portfolio Optimization without the Concavification Principle

The problems of non-concave portfolio optimization appear in many areas of finance and economics, such as in behavior economics, incentive schemes, and goal problems. Almost all of existing literature solves these problems using the concavification principle. We provide a general framework for numerically solving non-concave portfolio optimization problems, where the concavification principle may not hold and the utility functions can be discontinuous. In particular, we find that adding portfolio constraints, which makes the concavification principle invalid, can significantly affect economic insights in the existing literature. Theoretically, we show that a monotone, stable, and consistent finite difference scheme is still convergent under the general framework.

This work is jointly with Min Dai, Steven Kou, and Xiangwei Wan.