SIAM Student Chapter @NUS

13th Symposium on Applied and Computational Mathematics, 2024

SIAM Student Chapter @NUS

- Homepage: https://siamnus.github.io/website/

Committee Members

- Prof. Bao Weizhu (matbaowz@nus.edu.sg, Faculty Advisor)
- Mr. Tang Tianyun (ttang@u.nus.edu , President)
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Date

- 28th May 2024 Tuesday

Sponsors

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

Plenary Speakers

- Prof. Nguyen Hung Minh Tan, Department of Mathematics
- Prof. Soh Yong Sheng, Department of Mathematics
- Prof. Tan Yan Fu, Vincent, Department of Mathematics

Student Speakers

- Guo Yue, Department of Mathematics
- Hou Yunlong, Department of Mathematics
- Li Jingyang, Department of Mathematics
- Li Zhixuan, Department of Mathematics
- Dr. Wang Shiwei, Institute of Operations Research and Analytics
- Dr. Xiao Nachuan, Institute of Operations Research and Analytics
- Zhang Yijiong, Department of Mathematics
- Zhao Jiaxi, Department of Mathematics

All are welcome!

Workshop program

All talks take place at S17 (Department of Mathematics) #04-06.

May 28 (Tuesday): 13th SIAM Student Chapter		
Time	Speaker	Title
8:55-9:00am	Opening remarks	
	Session chair: Tang Tianyun	
9:00-9:45am	Prof. Nguyen Minh Tan **(Plenary)**	TBD
9:45-10:30am	Prof. Soh Yong Sheng **(Plenary)**	TBD
10:30-11am	Coffee break	
11:00-11:25am	Dr Xiao Nachuan	SGD-type Methods with Guaranteed Global Stability in Nonsmooth Nonconvex Optimization
11:30am-12pm	Li Jingyang	TBD

12pm-2pm	Lunch reception	
	Session chair: Tang Tianyun	
2pm-2:45pm	Prof. Tan Yan Fu, Vincent **(Plenary)**	Optimal Clustering with Bandit Feedback
2:45-3:10pm	Hou Yunlong	TBD
3:10-3:35pm	Dr Wang Shiwei	Strong Variational Sufficiency for Nonlinear Semidefinite Programming and its Implications
3:35-4:00pm	Coffee break	
4:00-4:25pm	Zhao Jiaxi	Mitigating distribution shift in machine learning-augmented hybrid simulation
4:25-4:50pm	Guo Yue	Learning Parametric Koopman Decompositions for Prediction and Control
4:50-5:15pm	Zhang Yijiong	Optimal Market Making under Model Uncertainty: A Reinforcement Learning approach
5:15-5:40pm	Li Zhixuan	Capillary folding of thin elastic sheets

Abstracts

Prof. Nguyen Minh Tan

TBD

Prof. Soh Yong Sheng

TBD

Dr Xiao Nachuan

SGD-type Methods with Guaranteed Global Stability in Nonsmooth Nonconvex Optimization

In this talk, we focus on providing convergence guarantees for variants of the stochastic subgradient descent (SGD) method in minimizing nonsmooth nonconvex functions. We first develop a general framework to establish global stability for general stochastic subgradient methods, where the corresponding differential inclusion admits a coercive Lyapunov function. We prove that, with sufficiently small stepsizes and controlled noises, the iterates asymptotically stabilize around the stable set of its corresponding differential inclusion. Then we introduce a scheme for developing SGD-type methods with regularized update directions for the primal variables. Based on our developed framework, we prove the global stability of our proposed scheme under mild conditions. We further illustrate that our scheme yields variants of SGD-type methods, which enjoy guaranteed convergence in training nonsmooth neural networks. In particular, by employing the sign map to regularize the update directions, we propose a novel subgradient method named the Sign-map Regularized SGD method (SRSGD). Preliminary numerical experiments exhibit the high efficiency of SRSGD in training deep neural networks.

Li Jingyang

TBD

Prof. Tan Yan Fu, Vincent

Optimal Clustering with Bandit Feedback

This work considers the problem of online clustering with bandit feedback. A set of arms (or items) can be partitioned into various groups that are unknown. Within each group, the observations associated to each of the arms follow the same distribution with the same mean vector. At each time step, the agent queries or pulls an arm and obtains an independent observation from the distribution it is associated to. Subsequent pulls depend on previous ones as well as the previously obtained samples. The agent's task is to uncover the underlying partition of the arms with the least number of arm pulls and with a probability of error not exceeding a prescribed constant δ. The problem proposed finds numerous applications from clustering of variants of viruses to online market segmentation. We present an instance-dependent information-theoretic lower bound on the expected sample complexity for this task, and design a computationally efficient and asymptotically optimal algorithm, namely Bandit Online Clustering (BOC). The algorithm includes a novel stopping rule for adaptive sequential testing that circumvents the need to exactly solve any NP-hard weighted clustering problem as its subroutines. We show through extensive simulations on synthetic and real-world datasets that BOC's performance matches the lower bound asymptotically, and significantly outperforms a non-adaptive baseline algorithm.

Joint work with Junwen Yang (IORA, NUS) and Zixin Zhong (University of Alberta). To appear in the Journal of Machine Learning

Hou Yunlong

TBD

Dr Wang Shiwei

Strong Variational Sufficiency for Nonlinear Semidefinite Programming and its Implications

Strong variational sufficiency is a newly proposed property, which turns out to be of great use in the convergence analysis of multiplier methods. However, what this property implies for non-polyhedral problems remains a puzzle. In this talk, we will introduce the equivalence between the strong variational sufficiency and the strong second order sufficient condition (SOSC) for nonlinear semidefinite programming (NLSDP), without requiring the uniqueness of multiplier or any other constraint qualifications. Based on this characterization, the local convergence property of the augmented Lagrangian method (ALM) for NLSDP can be established under strong SOSC in the absence of constraint qualifications. Moreover, under the strong SOSC, we can apply the semi-smooth Newton method to solve the ALM subproblems of NLSDP as the positive definiteness of the generalized Hessian of augmented Lagrangian function is satisfied.

Zhao Jiaxi

Mitigating distribution shift in machine learning-augmented hybrid simulation

We study the problem of distribution shift generally arising in machine-learning augmented hybrid simulation, where parts of simulation algorithms are replaced by data-driven surrogates. A mathematical framework is established to understand the structure of machine-learning augmented hybrid simulation problems and the cause and effect of the associated distribution shift. We show correlations between distribution shift and simulation error both numerically and theoretically. Then, we propose a simple methodology based on tangent-space regularized estimator to control the distribution shift, thereby improving the long-term accuracy of the simulation results. In the linear dynamics case, we provide a thorough theoretical analysis to quantify the effectiveness of the proposed method. Moreover, we conduct several numerical experiments, including simulating a partially known reaction-diffusion equation and solving Navier-Stokes equations using the projection method with a data-driven pressure solver. In all cases, we observe marked improvements in simulation accuracy under the proposed method, especially for systems with high degrees of distribution shift, such as those with relatively strong non-linear reaction mechanisms, or flows at large Reynolds numbers.

Guo Yue

Learning Parametric Koopman Decompositions for Prediction and Control

We present an approach to constructing approximate Koopman-type decompositions for dynamical systems depending on static or time-varying parameters. Our method simultaneously constructs an invariant subspace and a parametric family of projected Koopman operators acting on this subspace. We parametrize both the projected Koopman operator family and the dictionary that spans the invariant subspace by neural networks, and jointly train them with trajectory data. We show theoretically the validity of our approach, and demonstrate via numerical experiments that it exhibits significant improvements over existing methods in solving prediction problems, especially those with large state or parameter dimensions, and those possessing strongly non-linear dynamics. Moreover, our method enables data-driven solution of optimal control problems involving non-linear dynamics, with some interesting implications on controllability.

Zhang Yijiong

Optimal Market Making under Model Uncertainty: A Reinforcement Learning approach

We study the optimal market-making problem in order-driven electronic markets, focusing on developing an interpretable quoting strategy and deriving a robust solution that excels amidst model ambiguity. We address two types of ambiguity in market dynamics transitions: variability in various parameters, ranging from order arrival intensities to price dynamics, and distributional variability, defined via Wasserstein uncertainty. To overcome technical challenges, we introduce a tractable model for limit order books using Markov decision processes and develop a model-based robust reinforcement learning method to navigate the complex optimization problem. Our framework enables the incorporation of realistic settings to accurately capture the intricacies of market microstructure and ensure sustainably superior performance under ever-changing and diverse market condi-

tions. Through simulations and real-data studies, we demonstrate the effectiveness of our approach, emphasizing the importance of accounting for model ambiguity. Additionally, our work presents a comprehensive framework that illustrates the application of advanced machine learning techniques in quantitative finance, offering a valuable blueprint for addressing similar challenges within this field.