The First HKUST SIAM Student Chapter Annual Meeting

Date: June 5, 2023

Venue: Room 2404, HKUST   Zoom ID: 946 8148 1819   Password: hkustsiam

Time	Speaker	Title
2:00pm-2:05pm	Opening	
	Session chair: Yahong Yang (HKUST)	
2:05pm-2:55pm	Yuan Lan (Huawei Hong Kong Research Center)	DOSnet as a Non-Black-Box PDE Solver: When Deep Learning Meets Operator Splitting
2:55pm-3:25pm	Yue Wu (HKUST)	Score-based Transport Modeling for Mean Field Fokker-Planck Equations
3:25pm-3:55pm	Jingfeng Wang (University of Macau)	Towards Automatic Highly Efficient DWR-based h-adaptive Method in Newton-GMG Framework for Steady Euler Equations
3:55pm-4:10pm	Break	
	Session chair: Yue Wu (HKUST)	
4:10pm-4:40pm	Paul Kwong Yu (De La Salle University)	Mathematical Modeling of Fluconazole Resistance in the Ergosterol Pathway of Candida albicans
4:40pm-5:10pm	Zetao Fei (HKUST)	IFF: A Super-resolution Algorithm for Multiple Measurements
5:10pm-5:40pm	Jingyang Li (HKUST)	Blessing of Online Tensor Learning and Computational and Statistical Tradeoffs
5:40pm-6:10pm	Indira Puteri Kinasih (Universiti Brunei Darussalam)	Exploring the Spatial Relationships of House Prices in Indonesia: A Statistical Modeling Approach

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY | DEPARTMENT OF MATHEMATICS

siam Society for Industrial and Applied Mathematics

Abstracts

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1 Yuan Lan (Huawei Hong Kong Research Center)

DOSnet as a Non-Black-Box PDE Solver: When Deep Learning Meets Operator Splitting

Abstract: Deep neural networks (DNNs) recently emerged as a promising tool for analyzing and solving complex differential equations arising in science and engineering applications. Alternative to traditional numerical schemes, learning-based solvers utilize the representation power of DNNs to approximate the input-output relations in an automated manner. However, the lack of physics-in-the-loop often makes it difficult to construct a neural network solver that simultaneously achieves high accuracy, low computational burden, and interpretability. In this talk: I present DOSnet, a learning-based PDE solver that leverages the classical operator splitting technique to design neural network architectures. Such non-black-box network design is constructed from the physical rules and operators governing the underlying dynamics, and is more efficient and flexible than the classical numerical schemes and standard DNNs. I show the application of DOSnet on several types of operator-decomposable PDEs, including nonlinear Schrödinger equations that have applications in optical fiber transmission systems. The experimental results show that DOSnet has better accuracy and lower computational complexity than numerical schemes and the baseline DNNs.

2 Yue Wu (HKUST)

Score-based Transport Modeling for Mean Field Fokker-Planck Equations

Abstract: We use the score-based transport modeling method to solve the mean-field Fokker-Planck equations, which we call MSBTM. We establish an upper bound on the time derivative of the Kullback-Leibler (KL) divergence to MSBTM numerical estimation from the exact solution, thus validates the MSBTM approach. Besides, we provide an error analysis for the algorithm. In numerical experiments, we study two types of mean-field Fokker-Planck equation and their corresponding dynamics of particles in interacting systems. The MSBTM algorithm is numerically validated through qualitative and quantitative comparison between the MSBTM solutions, the results of integrating the associated stochastic differential equation and the analytical solutions if available.

3 Jingfeng Wang (University of Macau)

Towards automatic highly efficient DWR-based h-adaptive method in Newton-GMG framework for steady Euler equations

Abstract: Mesh adaptation is one of the crucial steps in solving computational fluid dynamics problems. However, the widespread adoption of this method has been limited by issues related to software complexity, inadequate error estimation capabilities, and complex geometries. In our previous work, we developed a highly efficient Newton-GMG solver that effectively solves the steady Euler equations using different modules. Additionally, we integrated the dual-weighted residual (DWR)-based h-adaptive method into our framework, which demonstrates precise performance in solving the target functional.

In this presentation, we will discuss further enhancements to the DWR-based h-adaptive method from two perspectives. Firstly, we analyze the dual consistency within this framework, leading to the development of algorithms that effectively reduce the degree of freedom. Secondly, we train convolutional neural networks to generate dual solutions, resulting in a time-saving improvement by an order

of magnitude. Furthermore, we design an automatic tolerance selection technique to expedite the calculation process. With these advancements, an automatic and highly efficient DWR-based h-adaptive method is implemented within our framework.

4 Paul Kwong Yu (De La Salle University)

Mathematical Modeling of Fluconazole Resistance in the Ergosterol Pathway of Candida albicans

Abstract: The significant increase in fluconazole-resistant Candida albicans calls for a need to search for other possible drug targets. In this study, we constructed a mathematical model, based from the data collected from the literature, of the ergosterol biosynthesis pathway in C. albicans. Interestingly, we found an increase in the susceptibility of C. albicans to fluconazole with increasing concentrations of the sterol-methyltransferase enzyme, making it a potential drug target as an adjunct to fluconazole.

5 Zetao Fei (HKUST)

IFF: A Super-resolution Algorithm for Multiple Measurements

Abstract: The problem of reconstructing one-dimensional point sources from their Fourier measurements in a bounded interval $[-\Omega, \Omega]$ is known to be challenging in the regime where the spacing of the sources is below the Rayleigh length $\frac{\pi}{\Omega}$. In this talk, we present a super-resolution algorithm, called Iterative Focusing-localization and Filtering (IFF), to resolve closely spaced point sources from their multiple measurements that are obtained by using multiple unknown illumination patterns. The new proposed algorithm requires no prior information about the source numbers and allows for a subsampling strategy that can circumvent the computation of singular-value decomposition for large matrices as in the usual subspace methods. In the talk, we will also discuss the theoretical results of the methods behind the algorithm. The derived results imply a phase transition phenomenon. Numerical results show that the algorithm can achieve a stable reconstruction for point sources with a minimum separation distance that is close to the theoretical limit as well as the phase transition phenomenon predicted by the theoretical analysis.

6 Jingyang Li (HKUST)

Blessing of Online Tensor Learning and Computational and Statistical Tradeoffs

Abstract: We investigate a generalized framework for estimating latent low-rank tensors in an online setting, encompassing both linear and generalized linear models. This framework offers a flexible approach for handling continuous or categorical variables. Additionally, we investigate two specific applications: online tensor completion and online binary tensor learning. To address these challenges, we propose the online Riemannian gradient descent algorithm, which demonstrates linear convergence and the ability to recover the low-rank component under appropriate conditions in all applications. Furthermore, we establish a precise entry-wise error bound for online tensor completion. Notably, our work represents the first attempt to incorporate noise in the online low-rank tensor recovery task. Intriguingly, we observe a surprising tradeoff between computational and statistical aspects in the presence of noise. Increasing the step size accelerates convergence but leads to higher statistical error, whereas a smaller step size yields a statistically optimal estimator at the expense of slower convergence. Moreover, we conduct regret analysis for online tensor regression. Under the fixed step-size regime, a fascinating *trilemma* concerning the convergence rate, statistical error rate, and regret is observed. With an optimal choice of step-size we achieve an optimal regret of $O(\sqrt{T})$. Furthermore, we extend our analysis to the adaptive setting where the horizon T is unknown. In this case, we demonstrate that by employing different step sizes, we can attain a statistically optimal error rate along with a regret of $O(\log T)$. To validate our theoretical claims, we provide numerical results that corroborate our findings and support our assertions.

7 Indira Puteri Kinasih (Universiti Brunei Darussalam)

Exploring the Spatial Relationships of House Prices in Indonesia: A Statistical Modeling Approach

Abstract: Spatial modeling plays a crucial role in understanding the dynamics of housing markets, particularly in rapidly developing regions. This study focuses on Lombok, an island in Indonesia experiencing significant urbanization and housing growth. The objective of this on going work is to explore the spatial patterns and determinants of housing prices using the Besag, York, and Mollié (BYM) model. The BYM model is a popular choice for spatial modeling due to its ability to account for both spatial autocorrelation and spatial heterogeneity. By incorporating neighborhood effects and spatial dependencies, the model enables a comprehensive analysis of the factors influencing housing prices in Lombok. To conduct the study, a dataset containing housing prices and associated covariates such as number of bedrooms, bathrooms, building area, land area, population density, and distance from public facilities (markets and hospitals) at the neighborhood level was collected. Data collection process was a combination of two techniques. Scraping with rvest and tidyverse in R was held to harvest housing prices and their attributes from two biggest Indonesia real estate website. The second technique involves acquiring spatially structured data from authoritative primary sources.