The Taiwan—Hong Kong Joint Conference on Applied Mathematics and Related Topics 2025

2025 臺港應用數學及相關問題研討會

National Sun Yat-sen University
台灣・高雄・中山大學
Kaohsiung, Taiwan.
May 23-25, 2025

Math, CUHK

國立中山大學 National Sun Yat-sen University
Department of Applied Mathematics 應用數學系

Math, HKBU

Organizers: 中山大學: 黃毅青 (WONG Ngai-Ching)

中文大學: 邵慰慈 (SHIU Wai Chee)，麥偉樑 (MAK Wai Leung, Hugo)

浸會大學: 林其鋒 (LAM Kei Fong, Andrew)，蔡沛樺 (CHOI Pui Wah)

This is the third event in this series, following those hosted by National Cheng Kung University in 2018 and National Chung Cheng University in 2024. Our aim is to provide an opportunity for mathematicians from Taiwan and Hong Kong to share research ideas and foster collaboration. Students are especially encouraged to participate as speakers.

Plenary speakers: DON Wai Sun (曾維新 HKBU), HON Yiu Chung Benny (韓耀宗 CUHK), LI Chi-Kwong (李志光 College of May and William, USA) , SHEN Chun-Yen (沈俊嚴 NTU), SHIU Wai Chee (邵慰慈 CUHK)

Confirmed speakers:

Hong Kong: (CUHK) CHOY, Zi Him Jason (蔡子謙), MAK Hugo Wai Leung (麥偉樑), WONG Chak Fu Jeff (黃澤富); **(HKBU)** CHAN Ting Fung (陳廷峰), HON Yu Sing Sean (韓汝星), LAM Kei Fong Andrew (林其鋒), LIU Hao (劉皓), MENG Xiao (孟瀟), PAN Junjun (潘珺珺), SU Yichen (蘇怡琛), WANG Xuanwu (王玄武), WU Tian (吳天), YANG Jingyu (楊晶宇), ZHANG Hao (張昊); **(HKU)** TSE Alvin Cheuk Hin (謝卓軒)

Taiwan: (NSYSU) CHEN Chih-Wei (陳志偉), CHUNG Szu-Chi (鍾思齊), HSU Po-Han (許柏翰), LI Tsung-Lin (李宗錂), LIN C.-H. Jephian (林晉宏), TAN Chee Han (陳志漢), SHIH Jia-Han (施嘉翰); **(Others),** HO Pak-Tung (何柏通, Tamkang), KE Wen-Fong (柯文峰 NCKU), LAM Ching-Hung (林正洪, AS), LAM, Wai-Kit (林偉傑, NTU), LI Jhih-Huang (李志煌, NTU), HSU Hsiang-Ling (許湘伶 NKU), HUANG Chih-Chiang (黃志強, NCCU), HUANG Hao-Wei (黃皓瑋, NTHU), Amir NOORIZADEGAN (NTU), TAM Bit-Shun (譚必信, Tamkang), TSAI Ming-Cheng (蔡明誠, NTUT), WANG Ya-Shu (王雅書, NCHU)

Sponsors: The Mathematical Society, Mathematics Research Promotion Center, Chinese University of Hong Kong, Hong Kong Baptist University, and National Sun Yat-sen University

The Taiwan—Hong Kong Joint Conference on Applied Mathematics and Related Topics 2025

“2025 臺港應用數學及相關問題研討會”議程

台灣・高雄・國立中山大學

2025.05.23-25

	5/23 (星期五)	5/24 (星期六)	5/25 (星期日)
8:45-9:25 am		李志光	沈俊嚴
9:30-10:00		Noorizadegan/ 林正洪	許柏翰/孟　瀟
10:00-10:30		施嘉翰/王雅書	謝卓軒/鍾思齊
10:30-10:45	休　　息		
10:45-11:15		蘇怡琛/黃皓瑋	陳志偉/韓汝星
11:15-11:45		黃澤富/蔡明誠	麥偉樑/李志煌
11:45-12:15		劉　皓/譚必信	何柏通/張　昊
12:15-13:45	午　　餐		
13:45-14:25	報到、註冊 及歡迎茶會	韓耀宗	
14:30-15:00		王玄武/林其鋒	
15:00-15:15	開 幕 式	休　　息	
15:15-15:45	邵慰慈 (15:15-15:55)	許湘伶/潘珺珺	
15:45-16:15		林偉傑/黃志強	
16:15-16:30	曾維新 (16:10-16:50)	休　　息	
16:30-17:00		陳志漢/陳廷峰	
17:00-17:30	李宗錂	吳　天/柯文峰	
17:30-18:00	林晉宏	楊晶宇/蔡子謙	
18:30-		晚　　宴	

註 1：平行場次，分別在兩個演講室進行。5/23 (SC4009-1)，5/24, 25(SC4009-1/4011)

註 2：拍團體照時間為 5/24, 12:20。

註 3：5/24 星期六晚宴，中山校內活動中心 73 階蔬食餐廳（歐式自助餐）。

註 4：5/25 星期日下午，自費參訪旗津燈塔、海灘、海鮮晚餐（下午 14:30 碧海良居集合出發）。

The Taiwan — Hong Kong Joint Conference
on Applied Mathematics and Related Topics 2025
2025 臺港應用數學及相關問題研討會

Department of Applied Mathematics
National Sun Yat-sen University
中山大學 應用數學系
Kaohsiung, Taiwan
May 23–25, 2025.

as of May 10, 2025

Friday, May 23, 2025

| 理學院大樓 Science Building 4th floor

13:50 – 15:00 Registration 註 冊

| 理學院大樓 SC 4009-1

Chair: Ngai-Ching WONG 黃毅青

15:00-15:15 Opening 開幕式

Jyh-Tsung LEE 李志聰 (Professor and Dean of Science, National Sun Yat-sen University, Taiwan)

Tsung-Lin LEE 李宗鍒 (Professor and Chair, Department of Applied Mathematics, National Sun Yat-sen University, Taiwan)

Wai Chee SHIU 邵慰慈 (Professor, Chinese University of Hong Kong, Hong Kong)

tea/coffee/snacks

15:15-15:55 Wai Chee SHIU 邵慰慈 (Chinese University of Hong Kong, Hong Kong) (page 30)

Face-magic labelings of some polygonal graphs.

tea/coffee/snacks

16:10-16:50 Wai Sun DON 曾維新 (Hong Kong Baptist University, Hong Kong) (page 16)

Fifth-order bound-, positivity-, and equilibrium-preserving affine-invariant AWENO scheme for two-medium γ-based model of stiffened gas.

TEA/COFFEE/SNACKS

17:00-17:30 Tsung-Lin LEE 李宗錂 (National Sun Yat-sen University, Taiwan) (page 23)

Computing the canonical decomposition of unbalanced tensors by homotopy method.

17:30-18:00 C.-H. Jephian LIN 林晉宏 (National Sun Yat-sen University, Taiwan) (page 25)

Spectral clustering: theory and practice.

Saturday, May 24, 2025

| 理學院大樓 SC 4009-1

Chair: Wen-Fong KE 柯文峰

8:45-9:25 Chi-Kwong LI 李志光 (College of William and Mary, USA) (page 24)

Linear preserver problems in quantum information science.

|| Parallel Session I: 理學院大樓 SC 4009-1

Chair: Wai Sun DON 曾維新

9:30-10:00 Amir NOORIZADEGAN (National Taiwan University, Taiwan) (page 28)

From meshless methods to deep learning: a conditioning perspective.

10:00-10:30 Jia-Han SHIH 施嘉翰 (National Sun Yat-sen University, Taiwan) (page 31)

Measuring multivariate regression association via spatial signs.

TEA/COFFEE/SNACKS

10:45-11:15 Yichen SU 蘇怡琛 (Hong Kong Baptist University, Hong Kong) (page 32)

Greedy trial subspace selection in meshfree time-stepping scheme with applications in coupled bulk-surface pattern formations.

11:15-11:45 Chak Fu Jeff WONG 黃澤富 (Chinese University of Hong Kong, Hong Kong) (page 36)

Analyzing a snake and ladder game with Markov chains.

11:45-12:15 Hao LIU 劉 皓 (Hong Kong Baptist University, Hong Kong) (page 25)

Operator learning and neural scaling laws.

‖ Parallel Session II: 理學院大樓 SC 4011

Chair: Chi-Kwong LI 李志光

9:30-10:00 Ching-Hung LAM 林正洪 (Academia Sinica, Taiwan) (page 22)

Automorphism groups for cyclic orbifolds of lattice VOAs.

10:00-10:30 Ya-Shu WANG 王雅書 (National Chung Hang University, Taiwan) (page 36)

Linear maps preserving disjoint idempotents.

TEA/COFFEE/SNACKS

10:45-11:15 Hao-Wei HUANG 黃皓瑋 (National Tsinghua University, Taiwan) (page 20)

Hadamard products of random matrices and their limiting spectral distributions.

11:15-11:45 Ming-Cheng TSAI 蔡明誠 (National Taipei University of Technology, Taiwan) (page 34)

Multiplicative trace and spectrum preservers on nonnegative and stochastic matrices.

11:45-12:15 Bit-Shun TAM 譚必信 (Tamkang University, Taiwan) (page 32)

On the maximal A_α-index of graphs with a prescribed number of edges.

Group Photo (Lobby of Science Building)
團體照 (理學院中庭)

Lunch

| 理學院大樓 SC 4009-1

Chair: Wai Chee SHIU 邵慰慈

13:45-14:25 Yiu Chung Benny HON 韓耀宗 (Chinese University of Hong Kong, Hong Kong) (page 18)

A novel highway network for surface reconstruction in computer graphics.

|| Parallel Session I: 理學院大樓 SC 4009-1

Chair: Jia-Han SHIH 施嘉翰

14:30-15:00 Xuanwu WANG 王玄武 (Hong Kong Baptist University, Hong Kong) (page 35)

Smoothing methods to estimate varying-coefficient additive models.

TEA/COFFEE/SNACKS

15:15-15:45 Hsiang-Ling HSU 許湘伶 (National Kaohsiung University, Taiwan) (page 19)

Optimal designs with multiple correlated responses for experiments.

15:45-16:15 Wai-Kit LAM 林偉傑 (National Taiwan University, Taiwan) (page 23)

Correlation decay and limit theorems in disordered monomer-dimer models.

TEA/COFFEE/SNACKS

16:30-17:00 Chee Han TAN 陳志漢 (National Sun Yat-sen University, Taiwan) (page 33)

Steklov eigenvalues of nearly hyperspherical domains.

17:00-17:30 Tian WU 吳 天 (Hong Kong Baptist University, Hong Kong) (page 37)

Exploring the cellular mechanisms of NAFLD progression in mouse liver.

17:30-18:00 YANG Jingyu 楊晶宇 (Hong Kong Baptist University, Hong Kong) (page 37)

A finite element/operator-splitting method for the Pucci's equation.

|| Parallel Session II: 理學院大樓 SC 4011

Chair: Tsung-Lin LEE 李宗鋮

14:30-15:00 Kei Fong Andrew LAM 林其鋒 (Hong Kong Baptist University, Hong Kong) (page 21)

Phase field models for two phase micropolar fluids with mixtures.

TEA/COFFEE/SNACKS

15:15-15:45 Junjun PAN 潘珺珺 (Hong Kong Baptist University, Hong Kong) (page 29)

Constrained quaternion matrix factorization with applications on image processing.

15:45-16:15 Chih-Chiang HUANG 黃志強 (National Chung Cheng University, Taiwan) (page 20)

Traveling waves of reaction-diffusion equation.

TEA/COFFEE/SNACKS

16:30-17:00 Ting Fung CHAN 陳廷峰 (Hong Kong Baptist University, Hong Kong) (page 13)

Analysis of a phase field topology optimization problem with Cosserat continuum and thermal dissipation.

17:00-17:30 Wen-Fong KE 柯文峰 (National Cheng Kung University, Taiwan) (page 21)

Maximum block intersection numbers for finite field generated 2-designs.

17:30-18:00 Zi Him Jason CHOY 蔡子謙 (Chinese University of Hong Kong, Hong Kong) (page 14)

Inverse problem of determining nonlinear coefficients arising in evolution equations.

Banquet at 18:30 pm

73 Steps Vegetarian Restaurant in campus

中山校內學生活動中心 73 階蔬食咖啡 (歐式自助餐)

Sunday, May 25, 2025

| 理學院大樓 SC 4009-1

Chair: Yiu Chung Benny HON 韓耀宗

8:45-9:25 Chun-Yen Shen 沈俊嚴 (National Taiwan University, Taiwan) (page 29)

Hausdorff dimension estimates for polynomial images.

|| Parallel Session I: 理學院大樓 SC 4009-1

Chair: Chun-Yen Shen 沈俊嚴

9:30-10:00 Po-Han HSU 許柏翰 (National Sun Yat-sen University, Taiwan) (page 20)

Log-correlation for shifted Dirichlet L-functions.

10:00-10:30 Alvin Cheuk Hin TSE 謝卓軒 (University of Hong Kong, Hong Kong) (page 34)

Quantised representations of integers as sum of four polygonal numbers.

TEA/COFFEE/SNACKS

10:45-11:15 CHEN Chih-Wei 陳志偉 (National Sun Yat-sen University, Taiwan) (page 13)

Convergence of Hessian estimator from random samples on a manifold with boundary.

11:15-11:45 Hugo Wai Leung MAK 麥偉樑 (Chinese University of Hong Kong, Hong Kong) (page 26)

Application of remote sensing, numerical modeling and data analytic approaches in pollutant retrieval and monitoring.

11:45-12:15 Pak-Tung HO 何柏通 (Tamkang University, Taiwan) (page 17)

Q-curvature.

|| Parallel Session II: 理學院大樓 SC 4011

Chair: Chee Han TAN 陳志漢

9:30-10:00 Xiao MENG 孟 瀟 (Hong Kong Baptist University, Hong Kong) (page 27)

Analysis and optimal control of a diffusive sir model on metric graph and sub-domains.

10:00-10:30 Szu-Chi CHUNG 鍾思齊 (National Sun Yat-sen University, Taiwan) (page 36)

A framework for Cryo-EM image segmentation with conditional random field.

TEA/COFFEE/SNACKS

10:45-11:15 Yu Sing Sean HON 韓汝星 (Hong Kong Baptist University, Hong Kong) (page 17)

Optimal preconditioners for nonsymmetric multilevel Toeplitz systems with application to solving non-local evolutionary PDEs.

11:15-11:45 Jhih-Huang LI 李志煌 (National Taiwan University, Taiwan) (page 24)

Periodic PushASEP model.

11:45-12:15 Hao ZHANG 張 昊 (Hong Kong Baptist University, Hong Kong) (page 32)

Neyman-Pearson classifier with successive convex approximation for imbalanced data.

Closing Remarks

Lunch

A half day tour to Cijin Island

星期日下午，自費參訪旗津燈塔、海灘、海鮮晚餐

Start at 14:30pm from Watermark Hotel-the Harbour 碧海良居集合出發

Abstracts

Analysis of a phase field topology optimization problem with Cosserat continuum and thermal dissipation

CHAN Ting Fung 陳廷峰

Hong Kong Baptist University 香港浸會大學

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Abstract

In this talk we will present some results on a phase field topology optimization problem for 3D printing applications. The model involved is a coupled system with Cosserat continuum mechanics and thermal spectral dissipation. We establish well-posedness and differentiability of the state systems, adjoint systems and prove the existence of minimizers and derive the first order optimality conditions.

This is a joint work with Ehsan-Ul-Haq and Kei Fong Lam (HKBU).

Convergence of Hessian estimator from random samples on a manifold with boundary

CHEN Chih-Wei 陳志偉

National Sun Yat-sen University 國立中山大學

E-mail: chencw@math.nsysu.edu.tw

Abstract

A common method for estimating the Hessian operator from random samples on a submanifold involves locally fitting a quadratic polynomial. Although widely used, it is unclear if this estimator introduces bias, especially in manifolds with boundaries and nonuniform sampling. We show that this estimator

asymptotically converges to the Hessian operator, with nonuniform sampling and curvature effects proving negligible, even near boundaries. Our analysis framework simplifies the intensive computations required for direct analysis.

Simultaneous Stable Determination of Quasilinear terms for Parabolic equations

CHOY Zi Him Jason 蔡子謙

Chinese University of Hong Kong 香港中文大學

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Abstract

We consider the inverse problem of simultaneously recovering two classes of quasilinear terms appearing in a parabolic equation from boundary measurements. It is motivated by several industrial and scientific applications, including problems of heat conduction and population dynamics, and we study the issue of stability. More precisely, we derive simultaneous Lipschitz and Hölder stability estimates for two separate classes of quasilinear terms. The analysis combines different arguments including the linearization technique with a novel construction of singular solutions and properties of solutions of parabolic equations with nonsmooth boundary conditions. These stability results may be useful for deriving the convergence rate of numerical reconstruction schemes.

This is a joint work with Dr. Yavar Kian.

A Framework for Cryo-EM Image Segmentation with Conditional Random Field

CHUNG Szu-Chi 鍾思齊

National Sun Yat-sen University 國立中山大學

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Abstract

Recent improvements in cryogenic electron microscopy (cryo-EM) instrumentation and image analysis algorithms have transformed structural biology by substantially enhancing resolution. A key preliminary task in cryo-EM involves differentiating particles from the background in micrographs —a challenge compounded by low signal-to-noise ratios (SNR), the presence of contaminants, contrast variations due to ice thickness, and clusters of particles in various sizes. Even though modern image segmentation methods can identify particles at the pixel level, low SNR still impedes the automated production of precise annotations needed for supervised training. Therefore, benchmarking these techniques is vital to uncover their advantages and drawbacks and to promote further refinements.

To overcome these challenges, we propose a new framework that generates segmentation maps from cryo-EM data to serve as ground truth labels. Our modular system accommodates a variety of segmentation models and loss functions and enhances predictions by integrating Conditional Random Fields (CRFs) with multiple solvers and reference maps, resulting in sharper boundaries and more detailed segmentation. This adaptability allows for optimal configurations tailored to specific datasets. When trained on a limited number of micrographs, our framework achieves over 90% in accuracy, recall, precision, Intersection over Union (IoU), and F1-score on synthetic data. Additionally, incorporating CRFs improves segmentation quality and recall in experimental data. Ultimately, our pipeline produces 3D density maps with higher resolution than those generated by existing particle picking methods in two experimental datasets.

Learning a generalized multiscale prolongation operator

CHUNG Tse Shun Eric 鍾子信

Chinese University of Hong Kong 香港中文大學

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Abstract

Multigrid preconditioners are one of the most efficient techniques for solving large sparse linear systems.

In this research, we address Darcy flow problems with random permeability using the conjugate gradient method, enhanced by a two-grid preconditioner based on a generalized multiscale prolongation operator, which has been demonstrated to be stable for high contrast profiles. To circumvent the need for repeatedly solving spectral problems with varying coefficients, we harness deep learning techniques to expedite the construction of the generalized multiscale prolongation operator. Considering linear transformations on multiscale basis have no impact on the performance of the preconditioner, we devise a loss function by the coefficient-based distance between subspaces instead of l^2-norm of the difference of the corresponding multiscale bases. We discover that leveraging the inherent symmetry in the local spectral problem can effectively accelerate the neural network training process. In scenarios where training data are limited, we utilize the Karhunen-Loève expansion to augment the dataset. Extensive numerical experiments with various types of random coefficient models are exhibited, showing that the proposed method can significantly reduce the time required to generate the prolongation operator while maintaining the original efficiency of the two-grid preconditioner. The research is partially supported by the Hong Kong RGC General Research Fund (Projects: 14304021 and 14302620).

Fifth-Order Bound-, Positivity-, and Equilibrium-Preserving Affine-Invariant AWENO Scheme for Two-Medium γ-based Model of Stiffened Gas

DON Wai Sun 曾維新

Hong Kong Baptist University 香港浸會大學

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Abstract

We describe a quasi-conservative finite difference AWENO scheme with the affine-invariant Z-type nonlinear weights (Ai-AWENO) for the γ-based model.

The shock-capturing scheme should always but often fail to preserve the constant velocity and pressure. One leading cause is that switching the equation of state between different mediums generates numerical oscillations around the medium interface. In the Ai-AWENO scheme, the conservative variables, instead of the primitive variables, are used, and the equilibriums of velocity and pressure are preserved. A hybrid flux-based bound- and positivity-preserving (BP-P) limiter, which is a convex combination of the high-order (for resolution) and first-order (for BP-P) numerical fluxes, is also implemented to enforce the physical constraints. The theoretical analysis yields the exact CFL conditions of the first-order Lax-Friedrichs numerical flux for the stiffened gas. The numerical diffusion coefficient depends nonlinearly on the local Mach number. Various one-, two-, and three-dimensional benchmark two-medium shock-tube problems illustrate the proposed scheme's high-order accuracy and enhanced robustness.

Q-curvature

HO Pak-Tung 何柏通

Tamkang University 淡江大學

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Abstract

In this talk, I will give the definition of the Q-curvature, which can be viewed as a generalization of the Gaussian curvature in dimension 2. After explaining some properties of the Q-curvature, I will talk about some results related to the Q-curvature flow.

Optimal Preconditioners for Nonsymmetric Multilevel Toeplitz Systems with Application to Solving Non-local Evolutionary PDEs

HON Yu Sing Sean 韓汝星

Hong Kong Baptist University 香港浸會大學

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Abstract

In this talk, we present a new preconditioning method for nonsymmetric multilevel Toeplitz systems, including those from evolutionary PDEs. We propose a symmetric positive definite multilevel Tau preconditioner that is efficient and optimal, ensuring mesh-independent convergence with the preconditioned generalized minimal residual method. Numerical examples highlight our method' s effectiveness, particularly for non-local, time-dependent PDEs solved in parallel.

This is joint work with Yuan-Yuan Huang, Lot-Kei Chou, and Siu-Long Lei.

A Novel Highway Network for Surface Reconstruction in Computer Graphics

HON Yiu Chung Benny 韓耀宗

Chinese University of Hong Kong 香港中文大學

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Abstract

Surface reconstruction from point clouds is a fundamental challenge in computer graphics and medical imaging. In this talk, we introduce a novel Square-Highway (SqrHw) Network to explore the application of advanced neural network architectures for an accurate and efficient reconstruction of surfaces from data points. Its performance alongside plain neural networks and a simplified highway network is illustrated through various numerical examples including the reconstruction of simple and complex surfaces, such as spheres, human hands, and intricate models like the Stanford Bunny. We also analyze the impact of factors such as the number of hidden layers, interior and exterior points, and data distribution on surface reconstruction quality. Our results show that the proposed SqrHw architecture outperforms most existing neural network configurations, achieving faster convergence and higher-quality surface reconstructions. Additionally, we demonstrate the SqrHw' s ability to

predict surfaces over missing data, a valuable feature for challenging applications like medical imaging. Furthermore, our study demonstrates that the proposed SqrHw network yields more stable weight norms and backpropagation gradients compared to the Plain Network architecture. This research not only advances the field of computer graphics but also holds utility for other purposes such as function interpolation and physics-informed neural networks, which integrate multilayer perceptrons into their algorithms.

Optimal designs with multiple correlated responses for experiments with mixtures.

HSU Hsiang-Ling 許湘伶

National University of Kaohsiung 國立高雄大學

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Abstract

A mixture experiment within the $(q-1)$-dimensional probability simplex represents a specialized experimental framework where q factors are non-negative and constrained by the sum-to-one condition. In this talk, we investigate the issue of the optimal approximate designs with the k-correlated response mixture experimental models. In the multiple correlated response mixture models, we explore the improvement design class, known as the complete class, in relation to the Kiefer ordering for a given design. Building on the complete class results, we analyze the properties of optimal designs for multiresponse mixture models by leveraging the well-established equivalence theorem. For specific multiresponse model settings under the D-optimal design criteria, the optimal results can reduce multiresponse experimental design problems to single-response experimental design problems. An illustrative example showcasing optimal designs for correlated response mixture experimental models is presented.

Key words: Design optimality, Invariant design, Kiefer ordering, Mixture experimental model, Weighted centroid design

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Log-correlation for shifted Dirichlet L-functions

HSU Po-Han 許柏翰

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Abstract

In this talk, we will begin with the motivation of the study of shifted Riemann zeta functions. Then we will briefly introduce Dirichlet L-functions. After the introduction of the main objects, we will introduce our main theorem: a central limit theorem regarding the "joint distribution" of the shifted Dirichlet L-functions.

Traveling Waves of Reaction-Diffusion Equations

HUANG Chih-Chiang 黃志強

National Chung Cheng University 國立中正大學

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Abstract

In the talk, I would like to introduce the traveling waves of the monostable and bistable reaction-diffusion equation in a real line and a cylinder. Applying variational methods, we could study the existence of traveling waves for reaction-diffusion equations. In addition, the traveling waves of FitzHugh-Nagumo type system are also constructed.

Hadamard products of random matrices and their limiting spectral distributions

Huang Hao-Wei 黃皓瑋

National Tsinghua University 國立清華大學

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Abstract

In this talk we shall present the limiting spectral distributions of the Hadamard products of random matrices GUE. In certain scenarios, the limiting spectral distributions of such random matrix models exist and can be described in terms of square free convolutions. One related question to square free additive convolution is to investigate when the multiplicative convolution of the semi-circular law and a probability law on the positive real line has a semi-circular law as a component in the free additive convolution. We shall answer this question by offering necessary and sufficient conditions.

Maximum block intersection numbers for finite field generated 2-designs

KE Wen-Fong 柯文峰

National Cheng Kung University 國立成功大學

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Abstract

Every nontrivial multiplicative subgroup of a finite field gives rise to a 2-design. The number of elements in the intersection of two distinct blocks of such a design is referred to as a block intersection number. It turns out that the maximum of the block intersection numbers depends on the block size and the characteristic of the field, and can be identified efficiently.

Phase field models for two phase micropolar fluids

LAM Kei Fong Andrew 林其鋒

Hong Kong Baptist University 香港浸會大學

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Abstract

Micropolar fluids are among the simplest cases of fluids with microstructures, where each fluid particle has its own internal rotations. Examples include ferrofluids, blood flows, bubbly liquids and liquid crystals, all of which play significant and important roles in various industries and also in the human body. Combining the seminal work of A. Cemal Eringen and coworkers, with the diffuse interface approach for multiphase fluid flow, we present some new diffuse interface models for binary mixtures of micropolar fluids that seem to be better amenable to further analysis. Using recent advances in the mathematical analysis of such types of models, we present some novel analytical results on existence of weak solutions for a particular diffuse interface model and, if time permits, we will discuss some asymptotic limits. This is a joint work with Kin Shing Chan, Baoli Hao and Bjorn Stinner.

Automorphism groups for cyclic orbifolds of lattice VOAs

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Abstract

We study the automorphism group of a cyclic orbifold of a vertex operator algebra associated with a rootless even lattice for a lift of a fixed-point free isometry. One main question is to determine if there are some automorphisms that are not induced from automorphisms of the original lattice vertex operator algebra. We will discuss some general methods and provide several explicit examples in this talk.

Correlation decay and limit theorems in disordered monomer-dimer model

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Abstract

Consider a finite graph G and put weights on the edges and on the vertices of G, where the edge-weights are i.i.d., and the vertex-weights are also i.i.d. that are independent of the edge-weights, with a possibly different distribution. Given a (partial) matching M of G, we define the total weight of the matching to be the sum of all weights of the edges in M together with those of the unmatched vertices. We would like to understand the maximal weight when the size of G is large. We show that this model exhibits a certain form of correlation decay, which allows us to prove a central limit theorem for the so-called free energy for the model (a quantity that is close to the maximal weight, but more "regular" and easier to handle) with an explicit convergence rate. We will also briefly mention how these can be extended to the maximal weight, under (much) stronger assumptions on the weights and the graph G. Based on joint work with Arnab Sen (Minnesota).

Computing the canonical decomposition of unbalanced tensors by homotopy method

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Abstract

The canonical decomposition of the tensor whose maximal dimension is greater than its rank is considered. The upper bound of rank is derived under which

computing the canonical decomposition is equivalent to solving a structured polynomial system that is determined by the full rank factorization of the matricization of the tensor. Under the generic uniqueness conditions, the CPD solutions of the system are isolated so that these solutions can be achieved by homotopy method.

Linear Preserver Problems in Quantum Information Science

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Abstract

Linear preserver problems involve the characterization of linear maps on matrices or operators that preserve certain properties.

In this talk, we will explore linear preserver problems that arise from questions in quantum information science. Recent results will be presented, along with a discussion of open problems in the area.

Periodic PushASEP model

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Abstract

It is a joint work with Axel Saenz (Oregon).

We are interested in an interacting particle system called PushASEP model, which is a natural generalization of the TASEP model. Instead of studying

the model on an infinite line, we look at a periodic ring, which brings us back to a finite-state Markov process.

More precisely, we are in the following setup. At time 0, N particles are distributed on a periodic ring of size L, and they move to the left and right according to specific rules. We want to understand the asymptotic behavior of such a system for large L and N with the ratio N/L fixed.

We will explain how to study the model using different approaches derived from contour integrals. We will also explain how to diagonalize the system. These methods allow us to establish results about fluctuations in the relaxation time-scale $t \sim L^{3/2}$, which can be described by distributions interpolating the Gaussian distribution and the Tracy-Widom distribution.

Spectral Clustering: Theory and Practice

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Abstract

Given a graph and a function on its vertices, how do we partition the vertices into clusters so that (1) vertices with similar function values are in the same cluster and (2) the induced subgraph on each cluster is connected as much as possible? Such a problem has applications in detecting the sources of air pollution, image segmentation, and so on. We will go through the theoretical background of this algorithm and demonstrate some of its applications.

Operator Learning and Neural Scaling Laws

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Abstract

Deep neural networks have demonstrated a great success in many applications. For operator learning and large language model, neural scaling laws are observed in many works. Most of the observed laws are power laws, i.e., the testing error can be written as a power of number of parameters or the number of training samples. However, theoretical explanations of the scaling laws are largely missing. In this presentation, we focus on operator learning and analyze the approximation and generalization error of some popular network architectures. We provide a theoretical explanation of neural scaling laws, and show that if the data has low-dimensional structures, one can achieve power laws.

Application of Remote Sensing, Numerical Modeling and Data Analytic Approaches in Pollutant Retrieval and Monitoring

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Abstract

Air pollution has become a global pressing environmental risk in recent decades, as it can seriously affect health qualities of citizens and diminish environmental quality in neighborhood levels. Thus, it is of paramount importance to acquire accurate scientific methodologies that are capable of monitoring fine-scale spatial and temporal distribution of major pollutants, for example PM2.5, NO2 and O3. This talk first focuses on exploring how various high-resolution satellite products, numerical modeling, data analytic techniques can be effectively synergized to build up a comprehensive geo-processing framework, for retrieving spatial maps of tropospheric column densities and ground concentrations of concerned major pollutants within specific spatial domains. The illustration, gradual refinement and inter-comparison of relevant algorithms and machine learning approaches for specific case studies will be explored, so that promising statistical results could eventually be obtained when the retrieved

datasets are validated against raw measurement datasets. The spatial plots obtained will also be inter-compared with satellite-based results observed from The Geostationary Environment Monitoring Spectrometer (GEMS) developed by Korean scientists, so that temporal and spatial pollutant trends and distributions can be more effectively identified and located, while crucial physical parameters that can affect our data-analytic framework will also be discussed. This does not only benefit the science and modeling communities, but also provides policymakers and local officials crucial references in laying down policies to combat highlighted environmental challenges. Respective limitations and ways of moving forward from various key focus topics will also be outlined at the end.

Keywords. Satellite Remote Sensing; Statistical Machine Learning Methods; Atmospheric Modeling;

Analysis and Optimal Control of a Diffusive SIR Model on Metric Graph and Sub-domains

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Abstract

In this work, a diffusive SIR model is analyzed on a coupled structure of metric graphs and subdomains. A weak formulation for the dynamics within the domains, along the edges, and at the vertices is developed. The well-posedness of the system, including the existence, uniqueness, and regularity of solutions, is analyzed using Galerkin approximations and energy estimates. In the context of optimal control, the adjoint system and optimality conditions are derived via a Lagrangian approach, resulting in a coupled system of state and adjoint equations. These results provide a mathematical framework for the analysis and optimal control of diffusive SIR models on mixed graph-continuum domains, with applications to modeling and managing of epidemic spread.

From Meshless Methods to Deep Learning: A Conditioning Perspective

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Abstract

In this talk, we discuss the conditioning challenges in Radial Basis Function (RBF) methods and introduce two key condition numbers: the effective condition number and our proposed evaluation condition number. The effective condition number has been successfully used to achieve highly accurate results in RBF-based function approximation and partial differential equation (PDE) solving. Our newly proposed evaluation condition number assesses the stability of RBFs, providing deeper insights into numerical robustness.

Together, these two condition numbers address uncertainties in RBF methods, including the choice of shape parameters and center point locations, leading to more stable results with smooth error profiles. To efficiently compute these condition numbers, we leverage randomized singular value decomposition and our novel singular value algorithm, significantly reducing computational cost.

Furthermore, we explore recent advancements in numerical methods for function approximation and PDE solving, including deep learning-based approaches. We introduce modern neural network architectures such as multilayer perceptrons and the Kolmogorov-Arnold network, highlighting their advantages and practical applications with illustrative examples.

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Constrained Quaternion Matrix Factorization with Applications on Image Processing

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Abstract

In this talk, we will introduce a simple model for RGB color and polarization images under a unified framework of quaternion nonnegative matrix factorization (QNMF) and present a hierarchical nonnegative least squares method to solve the factor matrices. The convergence analysis of the algorithm is discussed as well. We test the proposed method in the polarization image and color facial image representation.

Like Nonnegative matrix factorization (NMF), QNMF is generally not unique. Inspired by Separable NMF, this talk will also present a novel low-rank quaternion linear mixing model called separable quaternion matrix factorization designed for polarized signals. Numerical experiments are given to demonstrate the effectiveness of the methods.

Hausdorff dimension estimates for polynomial images

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Abstract

In this talk, I will first briefly review the history of sum-product estimates in the setting of finite fields and mention the applications of sum-product type problems. Then I will start introducing the celebrated result of Bourgain about the discretized sum-product estimates and the applications to geometric measure theory problems. Finally I will talk about our recent results about expanding polynomials in terms of Hausdorff dimension and discuss their sum-product phenomena.

Face-magic Labelings of Some Polygonal Graphs

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Abstract

For $n \geq 3$, a cycle with n vertices is denoted by C_n. For a simple connected plane graph $G = (V, E)$ naturally embedded in $\mathbb{R}^2$, let $\mathcal{F}(G)$ denote the set of faces of G. Then, G is called a *C_n-face-magic* graph if there exists a bijection $f : V(G) \to \{1, 2, \ldots, |V(G)|\}$ such that for every $F \in \mathcal{F}(G)$ with $F \cong C_n$, the sum of all the vertex labels along C_n is a constant S. Here, the constant S is called a *C_n-face-magic value* of G.

1. A connected finite subgraph of a regular tessellation consisting of equilateral triangles (sharing a common edge or edges) is called a *triomino*.
2. A connected finite subgraph of a regular tessellation consisting of regular hexagons (honeycombs) is called a *honeycomb graph*.

3. A connected finite subgraph of a regular tessellation consisting of squares is called a *polyomino*.

In this talk, we shall show C_n-face-magicness for the above graphs for an appropriate n, respectively. Also, we shall extend some labeling process to m-gonal graph.

Measuring multivariate regression association via spatial signs

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Abstract

In this presentation, we propose a regression association measure aiming at the predictability of a multivariate outcome $\mathbf{Y}$ from a multivariate covariate $\mathbf{X}$, where the dimensions of $\mathbf{X}$ and $\mathbf{Y}$ can be different. To achieve this goal, we first generalize the conventional Kendall' s tau to assess association between two random vectors, and then apply it to two independent replications from the conditional distribution of $\mathbf{Y}$ given $\mathbf{X}$, namely $\mathbf{Y}$ and $\mathbf{Y}'$, to measure the predictability of $\mathbf{Y}$ from $\mathbf{X}$. The proposed measure can be expressed as the proportion of the variance of some function of $\mathbf{Y}$ that can be explained by $\mathbf{X}$, indicating that the measure has an interpretation in terms of predictability. Based on the proposed measure, we further define a conditional regression association measure, which can be utilized to perform variable selection. Since our measure is based on two independent replications from the conditional distribution, a simple nonparametric estimation method based on nearest neighbor is available. Simulations are carried out to examine the performance of the proposed variable selection algorithm and real data examples are analyzed for illustration.

This is a joint work with Dr. Yi-Hau Chen (Academia Sinica).

Greedy Trial Subspace Selection in Meshfree Time-Stepping Scheme with Applications in Coupled Bulk-Surface Pattern Formations

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Abstract

Combining kernel-based collocation methods with time-stepping methods to solve parabolic partial differential equations can potentially introduce challenges in balancing temporal and spatial discretization errors. Typically, using kernels with high orders of smoothness on some sufficiently dense set of trial centers provides high spatial approximation accuracy that can exceed the accuracy of finite difference methods in time. The paper proposes a greedy approach for selecting trial subspaces in the kernel-based collocation method applied to time-stepping to balance errors in both well-conditioned and ill-conditioned scenarios. The approach involves selecting trial centers using a fast block-greedy algorithm with new stopping criteria that aim to balance temporal and spatial errors. Numerical simulations of coupled bulk-surface pattern formations, a system involving two functions in the domain and two on the boundary, illustrate the effectiveness of the proposed method in reducing trial space dimensions while maintaining accuracy.

On the maximal A_α-index of graphs with a prescribed number of edges

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Abstract

For any real number $\alpha \in [0,1]$, by the A_α-*matrix* of a graph G we mean the matrix $A_\alpha(G) = \alpha D(G) + (1-\alpha)A(G)$, where $A(G)$ and $D(G)$ are the adjacency matrix and the diagonal matrix of vertex degrees of G, respectively. The largest eigenvalue of $A_\alpha(G)$ is called the A_α-index of G. Chang and Tam (2023) have solved the problem of determining graphs with maximal A_α-index over $\mathcal{G}(n,m)$, the class of graphs with n vertices and m edges, for $\alpha \in [\frac{1}{2}, 1)$ and $1 \leq m \leq 2n-3$. In the same paper, they posed the problem of characterizing graphs in $\mathcal{G}(n,m)$ that maximize the A_α-index for $0 < \alpha < \frac{1}{2}$ and $m \leq n-1$. In this work, it is noted that, for any $\alpha \in [0,1)$, the problem of characterizing graphs with maximal A_α-index over $\mathcal{G}(n,m)$ with $m \leq n-1$ is equivalent to the problem of characterizing graphs with maximal A_α-index over $\mathcal{S}(m)$, the class of graphs with m edges. In connection with the latter problem, we pose the following conjecture: Let $m \geq 3$ be a positive integer and suppose that $m = \binom{d}{2} + t$ with $0 \leq t < d$. There exists a real number α_0, $\alpha_0 = \frac{1}{2}$ for $m = 3$ and $\alpha_0 \in [0, \frac{1}{2})$ for $m \geq 4$, such that for any $\alpha \in [0,1)$, C^m_{d+1} (replaced by K_d, in case $t = 0$), where C^m_n denotes the quasi-complete graph with n vertices and m edges, or $K_{1,m}$ is the unique connected graph with m edges that maximize the A_α-index over $\mathcal{S}(m)$, depending on whether $\alpha \in [0, \alpha_0)$ or $\alpha \in (\alpha_0, 1)$; when $\alpha = \alpha_0$, there are exactly two connected graphs that maximize the A_α-index over $\mathcal{S}(m)$, namely, C^m_{d+1} (or K_d, in case $t = 0$) and $K_{1,m}$. The conjecture is established when $t = 0$.

Co-author(s): Ting-Chung Chang

Steklov eigenvalues of nearly hyperspherical domains

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Abstract

We consider Steklov eigenvalues of nearly hyperspherical domains in dimensions 4 or higher. Using perturbation methods, we compute the first-order asymptotic expansion for these Steklov eigenvalues and show that the first-order perturbations are eigenvalues of a Hermitian matrix, whose entries can

be written explicitly in terms of Pochhammer's and Wigner 3j-symbols. We analyse the asymptotic expansion and establish the following isoperimetric results for the problem of maximising volume-normalised Steklov eigenvalues: (i) for an infinite subset of Steklov eigenvalues, the ball is a stationary point, and (ii) for a different infinite subset of Steklov eigenvalues, the ball is not a maximiser.

Multiplicative trace and spectrum preservers on nonnegative and stochastic matrices

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Abstract

In this talk, we mainly explore multiplicative trace and spectrum preservers on the set of nonnegative and stochastic matrices. We will give concrete description of trace and spectrum preservers on the sets of nonnegative matrices, doubly stochastics, row stochastic, and column stochastic, respectively. Some related results and examples are provided.

Quantised representations of integers as sum of four polygonal numbers

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Abstract

The famous Lagrange's four square theorem states that every positive integers can be written as the sum of four squares. With the use of modular forms,

one can obtain an expression for the number of representations of a positive integers as the sum of four squares. Similar expressions can also be obtained with the case of general polygonal numbers replacing the squares. However, it was once thought that when replacing the general polygonal numbers with polygonal numbers, one cannot obtain an analogous result due to losing the modularity of the generating function used in the calculations. By using recently developed modular properties on the false theta function, K. Bringmann, M.-J. Jang, B. Kane, and A.C.H. Tse was able to obtain a relationship between the representations on the case with polygonal numbers and the case with general polygonal numbers, including an error term that is small enough to obtain useful results. In my talk, I will talk about the work I have done to obtain a quantised version of the above result, in the process improving the bounds used on such as the Kloosterman sums, to obtain a result with a more optimised error term.

Smoothing Methods to Estimate Varying-Coefficient Additive Models

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Abstract

As extensions to linear models, varying-coefficient models and additive models have been both studied for a long time, while their combination was then proposed as varying-coefficent models as a novel tool for tackling with functional data firstly. However, with the limitations of the original estimating method, which requires the both the densily recorded functional method and time-dependent covariates simultaneously, we propose new similar smoothing methods for estimation which ensure the accuracy and applicability at the same time. A simulation study and real-data example then illustrate the proposed methods.

Linear maps preserving disjoint idempotents

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Abstract

Let $\mathbf{M}_n(\mathbb{F})$ denote the set of all $n \times n$ matrices and $\mathbf{S}_n(\mathbb{F})$ denote the set of symmetric $n \times n$ matrices over a field $\mathbb{F}$, respectively. In this talk, I will present a characterization of linear maps on $\mathbf{M}_n(\mathbb{F})$ and $\mathbf{S}_n(\mathbb{F})$ that send disjoint rank one idempotents to disjoint idempotents. As an application, I will also characterize linear maps on $\mathbf{M}_n(\mathbb{F})$ and $\mathbf{S}_n(\mathbb{F})$ that preserve matrices annihilated by a fixed polynomial under certain assumptions.

Analyzing a Snake and Ladder Game with Markov Chains

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Abstract

The game of Snakes and Ladders symbolizes life' s journey, with ladders representing fortunate times and snakes representing difficult experiences. Just as players move up and down the board, life is full of ups and downs driven by luck and misfortune. This talk uses the modified Engel algorithm with discrete Markov Chains to model the game of Snakes and Ladders over time. It analyzes the expected time to absorption, the variance of the time to absorption, the expected number of visits to transient states, and the expected time to absorption at each state. The probability distribution for the time to absorption can be analyzed using simulation. The distribution of the difference between the state of the winner (necessarily 100) and the state of the second-place player changes as the number of players increases. Simulations with

one, two, and three dice are also discussed. These results can be used in classroom teaching to broaden strategies and skills for studying the applications of games of chance and recreational mathematics. Students gain a positive mindset and motivation in learning mathematical models and mathematical modelling process.

Exploring the Cellular Mechanisms of NAFLD Progression in Mouse Liver

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Abstract

Nonalcoholic fatty liver disease (NAFLD) encompasses a spectrum of liver conditions, from benign nonalcoholic fatty liver (NAFL) with simple steatosis to severe nonalcoholic steatohepatitis (NASH), which can progress to cirrhosis and hepatocellular carcinoma (HCC). Studying the progression of NAFLD at the molecular and cellular levels is crucial due to its projected rise as the leading cause of liver transplantation by 2030 and the limited therapeutic options resulting from an incomplete understanding of its underlying mechanisms. In this study, we employ statistical and mathematical methods, including clustering, permutation-based significance assessment, and network analysis, to analyze single-cell RNA sequencing (scRNA-seq) data from liver samples of healthy mice and those with diet-induced NAFL/NASH. Our findings reveal significant changes in liver macrophage clusters and alterations in cell – cell communication, gene regulation, and pathway enrichment associated with the high-fat diet treatment. This research provides theoretical support for the identification of potential targets for novel therapies to address the growing burden of NAFLD.

A Finite Element/Operator-Splitting Method for the Pucci's Equation

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Abstract

In this article, we present a finite element/operator-splitting method to approximate fully nonlinear elliptic equations involving the Pucci's operator. Our approach is based on converting Pucci's equation to a Monge-Ampère type equation and applying regularization. We then utilize the operator-splitting method for a corresponding flow problem, combined with a mixed finite element approximation. At each time step, our algorithm reduces to solving a Poisson-Dirichlet problem and an ordinary differential equation with an explicit solution. Numerical results demonstrate the efficiency and robustness of this method across a wide range of problems in different settings.

Neyman-Pearson Classifier with Successive Convex Approximation for Imbalanced Data

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Abstract

The task of binary classification and prediction has been a significant focus of research due to its wide application. For the priority of the classification accuracy of a particular class, the Neyman-Pearson (NP) paradigm is developed to control the classification error of the prioritized class under a pre-specified level. The splitting of samples serves a vital role for most of the existing NP classifiers, which ensures control of the prioritized class with a high chance. The limitation of excluding a proportion of samples from the training procedures provides motivation for proposing a novel algorithm that addresses these drawbacks. In order to maximize the utilization of all available samples, we

propose a new classifier from an empirical optimization perspective. Under the linear assumptions, we leverage the difference-of-convex approximation and successive convex approximation to solve the classification problem with the NP paradigm. Our method has the capability to control the classification error of the prioritized class both at the sample and population levels. By incorporating a penalty term within the algorithm, we can ensure that the error is controlled. Numerical study and real-world applications demonstrate the effectiveness of the proposed method.

國立中山大學地圖 National Sun Yat-sen University Campus Map

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