天元數學國際交流中心
Tianyuan Mathematics Research Center

天元数学国际交流中心
计算调和分析与数据科学研讨会
Tianyuan Mathematics Research Center
TY-2024-C-048：Workshop on Computational Harmonic Analysis and Data Science

2025 年 11 月 30 日-12 月 6 日
November 30 - December 6, 2025

组织者 Organizers

董彬（北京大学）Bin DONG, Peking University

李松（浙江大学）Song LI, Zhejiang University

魏轲（复旦大学）Ke WEI, Fudan University

凌舒扬（上海纽约大学）Shuyang LING, NYU Shanghai

会议信息 Conference Information

数据科学和机器学习在过去 10 年取得了令人瞩目的成果，特别是在类如自然语言处理、计算机视觉等领域取得了令人印象深刻的成果。与此同时，现代的数据科学领域也涌现出了很多重要的挑战：例如深度神经网络的可解释性、可信任性，以及如何处理大规模数据处理和学习任务中的复杂计算问题等。从根本上，上述重要问题都是具备高度学科交叉的，因而求解它们将高度需要数学家、统计学家、计算机科学家和工程师之间的密切合作。因此，本研讨会的重要目的是把相关领域内最活跃的资深和青年专家聚在一起，共同探讨上述挑战的解决方案。本次研讨会将围绕以下主题：

- 调和分析和深度学习的融合；
- 高维数据的表示和抽样；
- 复杂数据集反问题和信号处理。

报到时间：11 月 30 日（周日）
报告时间：12 月 1 日-12 月 5 日
离会时间：12 月 5 日下午或者 12 月 6 日全天
地点：天元数学国际交流中心，云南省昆明市宜良县
注意事项：
1. 本次会议得到天元数学国际交流中心（下称中心）资助，参会人员的住宿及餐饮由中心承担，其余费用由参会人员自行承担。
2. 中心安排接送，由中心往返昆明南站或昆明长水机场。
3. 中心离古城镇中心卫生院约 40 分钟行程，离宜良县医人民院约 1 小时行程，离石林彝族自治县人民医院约 1 小时行程。建议适当随时携带一些必备药品。为医疗应急，中心常备蚊虫叮咬药品、 999 感冒灵、连花清瘟胶囊、云南白药喷雾剂、创口贴等药品。
4. 其余相关信息可参见中心网站：http://tianyuan.amss.ac.cn/syyj/index.html

会议日程 Conference Schedule

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Yang WANG</td><td>孙文昌
Wenchang SUN</td><td>蔡剑锋
Jianfeng CAI</td><td>夏冬
Dong XIA</td><td>包承龙
Chenglong BAO</td><td rowspan="11">自由讨论
Free Discussion</td></tr>
<tr><td>9:10-9:50</td><td>李松
Song LI</td><td>王建军
Jianjun WANG</td><td>曾铁勇
Tieyong ZENG</td><td></td><td>成诚
Cheng CHENG</td></tr>
<tr><td>9:50-10:20</td><td colspan="5">茶歇</td></tr>
<tr><td>10:20-
11:00</td><td>张小群
Xiaoqun ZHANG</td><td>杨在
Zai YANG</td><td>林绍波
Shaobo LIN</td><td>马俊杰
Junjie MA</td><td>栗会平
Huiping LI</td></tr>
<tr><td>11:00-
11:40</td><td>温金明
Jinming WEN</td><td>夏羽
Yu XIA</td><td>杨建斌
Jianbin YANG</td><td>徐孜立
Zili XU</td><td></td></tr>
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14:00</td><td colspan="5">午餐</td></tr>
<tr><td>14:00-
14:40</td><td></td><td>沈益
Yi SHEN</td><td rowspan="5">自由讨论
与活动
Free Discussion/
Excursion</td><td>魏轲
Ke WEI</td><td rowspan="5">自由讨论
Free Discussion</td></tr>
<tr><td>14:40-
15:20</td><td>汪鹏
Peng WANG</td><td>吴磊
Lei WU</td><td>张耀宇
Yaoyu ZHANG</td></tr>
<tr><td>15:20-
16:10</td><td colspan="2">茶歇</td><td>茶歇</td></tr>
<tr><td>16:10-
16:50</td><td>李根
Gen LI</td><td>杨睿逸
Ruiyi YANG</td><td></td></tr>
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17:30</td><td>梁经纬
Jingwei LIANG</td><td></td><td></td></tr>
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12 月 1 日 December 1, 2025			
时间 Time	报告人 Speaker	报告题目 Title	主持人 Chair
8:30-9:10	汪扬 Yang WANG 香港大学 University of Hong Kong	Deep Generative Learning and Schrödinger Bridge	
9:10-9:50	李松 Song LI 浙江大学 Zhejiang University	Stable Phase Retrieval: Optimal Rates in Poisson and Heavy-tailed Models	
茶歇 Tea Break			
10:20-11:00	张小群 Xiaoqun ZHANG 上海交通大学 Shanghai Jiaotong University	Flow based generative models for medical image synthesis	
11:00-11:40	温金明 吉林大学 Jilin University	Confined Orthogonal Matching Pursuit for Sparse Random Combinatorial Matrices	
午餐 Lunch Break			
14:00-14:40			
14:40-15:20	汪鹏 Peng Wang 澳门大学 University of Macau	Error Bound Analysis for the Regularized Loss of Deep Linear Neural Networks	
茶歇 Tea Break			
16:10-16:50	李根 Gen LI 香港中文大学	Faster Convergence and Acceleration for Diffusion-Based Generative Models	
16:50-17:30	梁经纬 Jingwei LIANG 上海交通大学	Adaptive Dimension Reduction for Overlapping Group Sparsity	
晚餐 Dinner			

12 月 2 日 December 2, 2025			
时间 Time	报告人 Speaker	报告题目 Title	主持人 Chair
8:30-9:10	孙文昌 Wenchang SUN 南开大学 Nankai University	Sampling Density for Gabor Phase Retrieval	
9:10-9:50	王建军 Jianjun WANG 西南大学 Southwest University	Tensor Modeling and Fast Randomized Computation in Image Processing	
茶歇 Tea Break			
10:20-11:00	杨在 Zai YANG 西安交通大学 Xi'an Jiaotong University	Pursuing the Limit of Chirp Parameter Identifiability: A Computational Approach	
11:00-11:40	夏羽 Yu XIA 杭州师范大学 Hangzhou Normal University	Stable Recovery Guarantees for Blind Deconvolution Problem under random mask assumption	
午餐 Lunch Break			
14:00-14:40	沈益 Yi SHEN 浙江理工大学 Zhejiang Sci-tech University	Some Open Problems in Compressed Sensing	
14:40-15:20	吴磊 Lei WU 北京大学 Peking University	A Functional Perspective for Understanding Scaling Laws	
茶歇 Tea Break			
16:10-16:50	杨睿逸 Ruiyi YANG 上海交通大学 Shanghai Jiaotong University	Model-free Estimation of Latent Structure via Multiscale Nonparametric Maximum Likelihood	
16:50-17:30			
晚餐 Dinner			

12 月 3 日 December 3, 2025			
时间 Time	报告人 Speaker	报告题目 Title	主持人 Chair
8:30-9:10	蔡剑锋 Jianfeng CAI 香港科技大学 Hongkong University of Science and Technology	Finding Low-Rank Matrix Weights in DNNs via Riemannian Optimization: RAdaGrad and RAadmW	
9:10-9:50	曾铁勇 Tieyong ZENG 广州南方学院 Nanfang College, Guangzhou	Kernel FISTA and Application to Image Deblurring	
茶歇 Tea Break			
10:20-11:00	林绍波 Shaobo LIN 西安交通大学 Xi'an Jiaotong University	Learning performance of Off-line Q-learning algorithms	
11:00-11:40	杨建斌 Jianbin YANG 河海大学 Ho-Hai University	Approximation from Noisy and Blurring Data	
午餐 Lunch Break			
自由讨论时间 Free Discussion			
晚餐 Dinner			

12 月 4 日 December 4, 2025			
时间 Time	报告人 Speaker	报告题目 Title	主持人 Chair
8:30-9:10	夏冬 Dong XIA 香港科技大学 Hongkong University of Science and Techology	Learning and Inference for Low-Rank Models	
9:10-9:50			
茶歇 Tea Break			
10:20-11:00	马俊杰 Junjie MA 中国科学院系统科学研究所 AMSS CAS	Optimality of Approximate Message Passing Algorithms for Spiked Matrix Models with Rotationally Invariant Noise	
11:00-11:40	徐孜立 Zili XU 华东师范大学	Interlacing Polynomial Method for Matrix Approximation	
午餐 Lunch Break			
14:00-14:40	魏轲 Ke WEI 复旦大学	On the convergence of policy gradient methods	
14:40-15:20	张耀宇 Yaoyu ZHANG 上海交通大学	Condensation sheds light to the mathematical foundation of deep neural networks	
茶歇 Tea Break			
16:10-16:50			
16:50-17:30			
晚餐 Dinner			

12 月 5 日 December 5, 2025			
时间 Time	报告人 Speaker	报告题目 Title	主持人 Chair
8:30-9:10	包承龙 Chenglong BAO 清华大学 Tsinghua University	An Optimal Newton-CG Method for Non-Convex Optimization	
9:10-9:50	成诚 Cheng CHENG 中山大学 Sun Yat-Sen University	Iterative polynomial approximation algorithms for inverse graph filters	
茶歇 Tea Break			
10:20-11:00	栗会平 Huiping LI 杭州师范大学 Hangzhou Normal University	Open Questions for Phase Retrieval Problem under Masked Fourier Measurements	
11:00-11:40			
午餐 Lunch Break			
自由讨论时间 Free Discussion			
12 月 6 日 December 6, 2025			
自由讨论时间 Free Discussion			

报告摘要与报告人信息(按拼音排序)

Talk Information and Speakers Biography (in alphebetical order)

1. **报告人：**包承龙（清华大学）

   Speaker：Chenglong BAO (Tsinghua University)

   报告题目 Title：An Optimal Newton-CG Method for Non-Convex Optimization

   报告摘要 Abstract：This talk presents an adaptive regularized Newton–CG method for solving nonconvex optimization problems. The proposed algorithm is parameter-free and does not require prior knowledge of the Hessian Lipschitz constant. From a theoretical perspective, we establish both optimal global complexity and local quadratic convergence. This result bridges the gap between global complexity guarantees and fast local convergence. Numerical experiments demonstrate the advantages of the method, including applications to training PINNs, where it achieves substantially lower training loss for solving various classes of PDEs.

2. **报告人：**蔡剑锋（香港科技大学）

   Speaker：Jianfeng CAI (Hong Kong University of Science and Technology)

   报告题目 Title：Finding Low-Rank Matrix Weights in DNNs via Riemannian Optimization: RAdaGrad and RAadmW

   报告摘要 Abstract：Finding low-rank matrix weights is a key technique for addressing the high memory usage and computational demands of large models. Most existing algorithms rely on the factorization of the low-rank matrix weights, which is non-unique and redundant. Their convergence is slow especially when the target low-rank matrices are ill-conditioned, because the convergence rate depends on the condition number of the Jacobian operator for the factorization and the Hessian of the loss function with respect to the weight matrix. To address this challenge, we adopt the Riemannian gradient descent (RGD) algorithm on the Riemannian manifold of fixed-rank matrices to update the entire low-rank weight matrix. This algorithm completely avoids the factorization, thereby eliminating the negative impact of the Jacobian condition number. Furthermore, by leveraging the geometric structure of the Riemannian manifold and selecting an appropriate metric, it mitigates the negative impact of the Hessian condition number. Ultimately, this results in our two plug-and-play optimizers: RAdaGrad and RAdamW, which are RGD with metrics adapted from AdaGrad and AdamW and restricted to the manifold. Our algorithms can be seamlessly integrated with various deep neural network architectures without any modifications. We evaluate the effectiveness of our algorithms through fine-tuning experiments on large language models and diffusion models. Experimental results consistently demonstrate that our algorithms provide superior performance compared to state-of-the-art methods. Additionally, our algorithm is not only effective for fine-tuning large models but is also applicable to deep neural network (DNN) compression.

3. **报告人：**成诚（中山大学）

   Speaker：Cheng CHENG (Sun Yat-Sen University)

   报告题目 Title：Iterative polynomial approximation algorithms for inverse graph filters

   报告摘要 Abstract：In this talk, I will introduce the graph Wiener filters to reconstruct deterministic and (wide-band) stationary graph signals from their observations corrupted by random noises, and the proposed distributed algorithms to implement Wiener filters and inverse filters on networks in which agents are equipped with a data processing subsystem for limited data storage and computation power, and with a one-hop communication subsystem for direct data exchange only with their adjacent agents. The proposed distributed polynomial approximation algorithm is an exponentially convergent quasi-Newton method based on Jacobi polynomial approximation and Chebyshev interpolation polynomial approximation to analytic functions on a cube.

4. **报告人：**李根（香港中文大学）

   Speaker：Gen LI (Chinese University of Hong Kong)

   报告题目 Title：Faster Convergence and Acceleration for Diffusion-Based Generative Models

   报告摘要 Abstract：Diffusion models, which generate new data instances by learning to reverse a Markov diffusion process from noise, have become a cornerstone in contemporary generative modeling. While their practical power has now been widely recognized, the theoretical underpinnings remain underdeveloped. Particularly, despite the recent surge of interest in accelerating sampling speed, convergence theory for these acceleration techniques remains limited. In this talk, I will first introduce an acceleration sampling scheme for stochastic samplers that provably improves the iteration complexity under minimal assumptions. The second part focuses on diffusion-based language models, whose ability to generate tokens in parallel significantly accelerates sampling relative to traditional autoregressive methods. Adopting an information-theoretic lens, we establish a sharp convergence theory for diffusion language models, thereby providing the first rigorous justification of both their efficiency and fundamental limits.

5. **报告人：**李松（浙江大学）

   Speaker：Song LI (Zhejiang University)

   报告题目 Title：Stable Phase Retrieval: Optimal Rates in Poisson and Heavy-tailed Models

   报告摘要 Abstract：The stable phase retrieval under Poisson and heavy-tailed noise remains a highly challenging open question in the field, with very limited existing research. This talk will focus on the theoretical analysis of this problem. By introducing a series of non-trivial mathematical techniques, we characterize the stable recovery of two well-known noise models. Our results show that, in the minimax sense, the derived upper error bounds are optimal. As a byproduct, we resolve several long-standing open questions that have

puzzled researchers for years. This work is jointly completed with my Ph.D. student Gao Huang and Deanna Needell (UCLA).

6. **报告人：**栗会平（杭州师范大学）
   Speaker： Huiping LI (Hangzhou Normal University)
   报告题目 Title： Open Questions for Phase Retrieval Problem under Masked Fourier Measurements
   报告摘要 Abstract： This talk focuses on several open questions for phase retrieval problem under masked Fourier measurements. Specifically, we shall introduce several algorithms for solving such problem and provide corresponding analysis about stability or optimal sampling complexity.

7. **报告人：**梁经纬
   Speaker： Jingwei LIANG (Shanghai Jiaotong University)
   报告题目 Title： Adaptive Dimension Reduction for Overlapping Group Sparsity
   报告摘要 Abstract： Typical dimension reduction techniques for sparse optimization involve screening strategies based on a dual certificate derived from the first-order optimality condition, approximating the gradients or exploiting some inherent low dimensional structure that an optimization algorithm promotes. Screening rules for overlapping group lasso are generally less developed because the subgradient structure is more complex and the link between sparsity pattern and the dual vector is generally indirect. In this talk, I will present a new strategy for certifying the support of the overlapping group lasso and demonstrate how this can be applied significantly accelerate the performance of numerical methods.

8. **报告人：**林绍波（西安交通大学）
   Speaker： Shaobo LIN (Xi'an Jiaotong University)
   报告题目 Title： Learning performance of Off-line Q-learning algorithms
   报告摘要 Abstract： The aim of this talk is to discuss the generalization performance of two modern offline Q-learning strategies: deep Q-learning and distributed Q-learning. In the framework of learning theory, we rigorously prove that these two Q-learning approaches outperform the traditional one by showing its good generalization error bound. In particular, our results show that the main reason of the success of deep Q-learning is due to the excellent performance of deep neural networks (deep nets) in capturing special properties of rewards such as the spatially sparse and piecewise constant rather than due to their large capacities. We also show that distributed Q-learning succeeds in reducing the computational burden without sacrificing the generalization performance.

9. **报告人：**马俊杰（中国科学院数学与系统科学研究院）
   Speaker： Junjie MA (Academy of Mathematics and Systems Science, CAS)

报告题目 Title： Optimality of Approximate Message Passing Algorithms for Spiked Matrix Models with Rotationally Invariant Noise

报告摘要 Abstract： We study the problem of estimating a rank one signal matrix from an observed matrix generated by corrupting the signal with additive rotationally invariant noise. We develop a new class of approximate message-passing algorithms for this problem and provide a simple and concise characterization of their dynamics in the high-dimensional limit. At each iteration, these algorithms exploit prior knowledge about the noise structure by applying a non-linear matrix denoiser to the eigenvalues of the observed matrix and prior information regarding the signal structure by applying a non-linear iterate denoiser to the previous iterates generated by the algorithm. We exploit our result on the dynamics of these algorithms to derive the optimal choices for the matrix and iterate denoisers. We show that the resulting algorithm achieves the smallest possible asymptotic estimation error among a broad class of iterative algorithms under a fixed iteration budget.

10. **报告人：**沈益（浙江理工大学）

Speaker： Yi SHEN (Zhejiang Sci-Tech University)

报告题目 Title： Some Open Problems in Compressed Sensing

报告摘要 Abstract： Compressed sensing has had a profound impact on signal processing and related fields. This report presents some progress on the open problems in compressed sensing. These include: the problem of constructing unions of orthonormal bases as proposed by Donoho and Gribonval; the stability of the split analysis model introduced by Candes et al.; open problem raised by Milenkovic regarding the Orthogonal Matching Pursuit (OMP) algorithm; convergence analyses of the BM3D algorithm proposed by Dabov et al.; and convergence analysis of the Binary Iterative Hard Thresholding (BIHT) algorithm proposed by Baraniuk et al..

11. **报告人：**孙文昌（南开大学）

Speaker： Wenchang SUN (Nankai University)

报告题目 Title： Sampling Density for Gabor Phase Retrieval

报告摘要 Abstract： Gabor phase retrieval stands for recovering a square integrable function up to a global phase from absolute values of its Gabor transform. In this paper, we study Gabor phase retrieval from discrete samples. We consider three types of sampling sequences, which include square root lattices, square root sequences on two intersecting lines and on three parallel lines respectively. In all cases we give the optimal sampling density for a sequence to do Gabor phase retrieval.

This is a joint work with Ting Chen and Hanwen Lu.

12. **报告人：**汪鹏（澳门大学）

Speaker： Peng WANG (University of Macau)

报告题目 Title：Error Bound Analysis for the Regularized Loss of Deep Linear Neural Networks

报告摘要 Abstract：The optimization foundations of deep linear networks have recently received significant attention. However, due to their inherent non-convexity and hierarchical structure, analyzing the loss functions of deep linear networks remains a challenging task. In this work, we study the local geometric landscape of the regularized squared loss of deep linear networks around each critical point. Specifically, we derive a closed-form characterization of the critical point set and establish an error bound for the regularized loss under mild conditions on network width and regularization parameters. Notably, this error bound quantifies the distance from a point to the critical point set in terms of the current gradient norm, which can be used to derive linear convergence of first-order methods. To support our theoretical findings, we conduct numerical experiments and demonstrate that gradient descent converges linearly to a critical point when optimizing the regularized loss of deep linear networks.

13. **报告人：**汪扬（香港大学）

Speaker：Yang WANG (University of Hong Kong)

报告题目 Title：Deep Generative Learning and Schrödinger Bridge

报告摘要 Abstract：Generative Adversarial Nets (GAN) have been one of the most exciting developments in machine learning and AI. But training of GAN is highly nontrivial. In this talk we propose to learn a generative model via entropy interpolation with a Schrödinger Bridge. The generative learning task can be formulated as interpolating between a reference distribution and a target distribution based on the Kullback-Leibler divergence. At the population level, this entropy interpolation is characterized via an SDE on [0,1] with a time-varying drift term. At the sample level, we derive our Schrödinger Bridge algorithm by plugging the drift term estimated by a deep score estimator and a deep density ratio estimator into the Euler-Maruyama method. Our theoretical results guarantee that the distribution learned by our approach converges to the target distribution. Experimental results on multimodal synthetic data and benchmark data support our theoretical findings and indicate that the generative model via Schrödinger Bridge is comparable state-of-the-art GANs, suggesting a new formulation of generative learning. We demonstrate its usefulness in image interpolation and image inpainting.

14. **报告人：**魏轲（复旦大学）

Speaker：Ke WEI (Fudan University)

报告题目 Title：On the convergence of policy gradient methods

报告摘要 Abstract：

个人简介：

15. **报告人：**吴磊（北京大学）

Speaker：Lei WU (Peking University)

报告题目 Title：A Functional Perspective for Understanding Scaling Laws

报告摘要 Abstract：Scaling laws for large language models (LLMs) reveal a striking empirical regularity: model performance improves according to predictable power laws as training data and compute scale. These laws have profoundly shaped the development of modern AI, yet their origins have remained largely empirical and theoretically unexplained. To uncover the underlying mechanism, we introduce power-law kernel regression, a minimal yet structurally faithful model that captures the essential ingredients driving scaling behavior. By analyzing its stochastic training dynamics through a continuous-time stochastic differential equation, we develop the framework of Functional Scaling Laws (FSL). FSL elevates classical scaling laws from predicting a final-step loss to predicting the entire loss trajectory. This functional viewpoint reveals an intrinsic-time structure that unifies training dynamics across model sizes, data scales, and learning-rate schedules. In particular, FSL provides a principled explanation for why widely used schedules—such as warmup–stable–decay—are so effective. Finally, experiments on LLM pre-training demonstrate that FSL offers a principled framework for both understanding and guiding large-scale model training.

16. **报告人：**夏冬（香港科技大学）

Speaker：Dong XIA (Hong Kong University of Science and Technology)

报告题目 Title：Learning and Inference for Low-Rank Models

报告摘要 Abstract：My talk will focus on the learning and inference for low-rank matrices and tensors in the presence of missing values, heterogeneity, and adaptively collected data. These problems pose significant challenges because the estimators are typically derived using iterative algorithms and involve multiple stages of spectral decomposition. Over the past several years, we have made several contributions in this field, including specially crafted estimation procedures, a powerful spectral representation formula, the double-sample debiasing approach, false-discovery control in multiple hypothesis testing, and debiasing using inverse propensity weighting.

17. **报告人：**夏羽（杭州师范大学）

Speaker：Yu XIA (Hangzhou Normal University)

报告题目 Title：Stable Recovery Guarantees for Blind Deconvolution Problem under random mask assumption

报告摘要 Abstract：This study addresses the blind deconvolution problem with modulated inputs, focusing on a measurement model where an unknown blurring kernel h is convolved with multiple random modulations of a signal x, subject to l2-bounded noise. Our work begins within a constrained least squares framework, where we establish a robust recovery bound for both h and x, demonstrating its near optimality up to a logarithmic factor.

Additionally, we present a new recovery scheme that leverages sparsity constraints on x. This approach significantly reduces the sampling complexity to the order of O(logn) when the non-zero elements of x are sufficiently separated. Furthermore, we demonstrate that incorporating sparsity constraints yields a refined error bound compared to the traditional constrained least squares model. These findings contribute to advancing the field of blind deconvolution and offer potential improvements in various applications requiring signal reconstruction from modulated inputs.

18. **报告人：**徐孜立（华东师范大学）

Speaker：Zili XU (East China Normal University)

报告题目 Title：Interlacing Polynomial Method for Matrix Approximation

报告摘要 Abstract：Matrix approximation is often a necessary step in the data processing workflow due to the common occurrence of high-dimensional datasets. A widely used method for matrix approximation is singular value decomposition (SVD). However, SVD produces factors that are complex combinations of the original rows or columns, which can hinder intuitive interpretation. To make the results more understandable, an alternative approach called subset selection has been developed. This approach selects a representative subset of columns and rows from the original matrix, yielding interpretable components that capture the underlying structure of the original matrix. This talk delves into the spectral norm aspect of the column subset selection problem and CUR matrix problem. By employing the method of interlacing polynomials, we show that the smallest possible spectral norm of a residual matrix can be bounded by the largest root of a related expected characteristic polynomial. Deterministic algorithms are provided for column subset selection problem and CUR matrix problem.

19. **报告人：**杨建斌（河海大学）

Speaker：Jianbin YANG (Hohai University)

报告题目 Title：Approximation from Noisy and Blurring Data

报告摘要 Abstract：Approximating functions from observed data is a fundamental problem in analysis and computation. While classical methods address the case of smooth functions with exact data, real-world observations are often contaminated by noise and blur, and the underlying functions may be nonsmooth. Effective approximation schemes therefore require both a denoising component and a representation that can capture nonsmooth features, such as sparse approximations in the wavelet domain. This talk presents a theoretical and practical framework for denoising- and deblurring-based approximation. We discuss approximation from both uniform grid data and scattered data, and highlight how the proposed approach balances noise reduction with accurate recovery of fine structures.

20. **报告人：**杨睿逸（上海交通大学）

Speaker：Ruiyi YANG (Shanghai Jiaotong University)

报告题目 Title：Model-free Estimation of Latent Structure via Multiscale Nonparametric Maximum Likelihood

报告摘要 Abstract：Multivariate distributions often carry latent structures that are difficult to identify and estimate, and which better reflect the data generating mechanism than extrinsic structures exhibited simply by the raw data. In this talk, we introduce a model-free approach for estimating such latent structures whenever they are present, without assuming they exist a priori. Given an arbitrary density, we construct a multiscale representation of it and propose data-driven methods for selecting representative models that capture meaningful discrete structure. Our approach uses a nonparametric maximum likelihood estimator to estimate the latent structure at different scales and we further characterize their asymptotic limits. By carrying out such a multiscale analysis, we obtain coarse-to-fine structures inherent in the original distribution, which are integrated via a model selection procedure to yield an interpretable discrete representation of it. As an application, we design a clustering algorithm based on the proposed procedure and demonstrate its effectiveness in capturing a wide range of latent structures.

21. **报告人：**杨在（西安交通大学）

Speaker：Zai YANG (Xi'an Jiaotong University)

报告题目 Title：Pursuing the Limit of Chirp Parameter Identifiability: A Computational Approach

报告摘要 Abstract：In this work, it is shown that a necessary condition for unique identifiability of K chirps from N regularly spaced samples of their mixture is $N\geq 2K$ when $K\geq 2$. A necessary and sufficient condition is that a rank-constrained matrix optimization problem has a unique solution; this is the first result of such kind. An algorithm is proposed to solve the optimization problem and to identify the parameters numerically. The lower bound of $N=2K$ is shown to be tight by providing diverse problem instances for which the proposed algorithm succeeds to identify the parameters. The advantageous performance of the proposed algorithm is also demonstrated compared with the state of the art.

22. **报告人：**王建军（西南大学）

Speaker：Jianjun WANG (Southwest University)

报告题目 Title：Tensor Modeling and Fast Randomized Computation in Image Processing

报告摘要 Abstract：In recent years, tensor-based methods for high-dimensional image processing have been extensively applied in fields such as computer vision, medical imaging, science and engineering, and remote sensing, achieving significant accomplishments. However, when dealing with large-scale high-dimensional image, existing tensor modeling

and computational methods suffer from issues such as inadequate data representation, low computational efficiency, high memory consumption, and limited flexibility. To address these problems, fast randomized algorithms for large-scale image compression and representation have been studied within popular and effective high-order tensor frameworks (e.g., T-SVD, Tucker, FCTN), leveraging sketching techniques from the field of randomized numerical algebra. Furthermore, advanced techniques such as non-convex regularization, gradient maps modeling, and intrinsic tensor decomposition have been employed to develop fast and accurate multi-dimensional image recovery methods. Theoretically, we provide theoretical error bound analysis for the proposed approximation algorithms and convergence analysis for the recovery algorithms. The proposed methods can be applied to a range of high-dimensional image processing tasks, including MRI/CT reconstruction, color image and video inpainting, hyperspectral image denoising, hyperspectral anomaly detection, and surveillance video background subtraction. Experimental results demonstrate that our methods outperform current competitive approaches in both quantitative metrics and visual effects.

23. **报告人：**温金明（吉林大学）

    Speaker： Jinming WEN (Jilin University)

    报告题目 Title： Confined Orthogonal Matching Pursuit for Sparse Random Combinatorial Matrices

    报告摘要 Abstract： This talk introduces a new Confined Orthogonal Matching Pursuit (Confined OMP) algorithm for sparse signal recovery over sparse random combinatorial matrices. The method constructs a confined set Γ by exploiting the near-zero entries in the measurement vector and proves that, for a class of "confined signals" with i.i.d. nonzero components, the true support is contained in Γ with probability one. This property allows a substantial reduction of redundant columns in the measurement matrix, thereby significantly decreasing the identification complexity of the recovery algorithm. A lower bound on the exact recovery probability is further derived, showing that when the number of measurements satisfies $m=2eK\ln(n-K)$, the recovery success probability is at least $1-1/(n-K)$. Simulation results demonstrate that the proposed method achieves orders-of-magnitude complexity reduction in low-sparsity regimes while maintaining competitive recovery performance and preserving robustness in noisy linear systems.

24. **报告人：**曾铁勇（广州南方学院）

    Speaker： Tieyong ZENG (Nanfang College Guangzhou)

    报告题目 Title：

    报告摘要 Abstract：

25. **报告人：**张小群（上海交通大学）

Speaker： Xiaoqun ZHANG (Shanghai Jiaotong University)

报告题目 Title： Flow based generative models for medical image synthesis

报告摘要 Abstract： This talk explores advancements in flow-based generative models for medical image synthesis, which are crucial for enhancing diagnostics, treatment planning, and data augmentation. Two novel approaches for bi-modality transfer are introduced. First, SyMOT-Flow minimizes discrepancies between distributions using optimal transport, enabling stable and interpretable image generation. Second, Bi-DPM improves efficiency and quality in bi-modality synthesis by avoiding complex ODE solvers and ensuring consistency across discrete time steps. Both methods are validated on MRI and CT datasets, demonstrating superior image quality and anatomical accuracy.

26. **报告人：** 张耀宇（上海交通大学）

Speaker： Yaoyu ZHANG (Shanghai Jiaotong University)

报告题目 Title： Condensation sheds light to the mathematical foundation of deep neural networks

报告摘要 Abstract： Condensation (also known as quantization, clustering, or alignment) is a widely observed phenomenon where neurons in the same layer tend to align with one another during the nonlinear training of deep neural networks (DNNs). It is a key characteristic of the feature learning process of neural networks. In recent years, to advance the mathematical understanding of condensation, we uncover structures regarding the dynamical regime, loss landscape and generalization for deep neural networks, based on which a novel theoretical framework emerges. This presentation will cover these findings in detail. First, I will present results regarding the dynamical regime identification of condensation at the infinite width limit, where small initialization is crucial. Then, I will discuss the mechanism of condensation at the initial training stage and the global loss landscape structure underlying condensation in later training stages, highlighting the prevalence of condensed critical points and global minimizers. Finally, I will present results on the quantification of condensation and its generalization advantage, which includes a novel estimate of sample complexity in the best-possible scenario. These results underscore the effectiveness of the phenomenological approach to understanding DNNs, paving a way for further developing deep learning theory.