

图像处理的数学与学习方法 研讨会

程序册



南开大学陈省身数学研究所

2026年6月5-8日

本次会议得到陈省身数学所、国家自然科学基金项目的资助

研讨会组委会

董 彬	北京大学
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高 冰	南开大学
乐航睿	南开大学
张道平	南开大学
赵亚楠	南开大学

会议详细日程

2026年6月5日（星期五）	
地点：南开大学嘉园宾馆	
14:00-21:00	报 到 地点：南开大学嘉园宾馆
2026年6月6日（星期六）上午 地点：陈省身数学研究所 216	
开幕式	
主持人：吴春林（南开大学）	
8:30-8:50	南开大学陈省身数学研究所麻小南所长讲话 会议组委会主席北京大学董彬教授讲话 合影
报告开始	
主持人：陈冲（中国科学院数学与系统科学研究院）	
8:50-9:25	Raymond Honfu Chan（岭南大学） Solving convolution-type integral equations with preconditioned neural operators
9:25-10:00	纪辉（新加坡国立大学） Advances in Self-Supervised Image Denoising: From Gaussian Noise to Real-World Noise
10:00-10:10	茶 歇
主持人：吴勃英（哈尔滨工业大学）	
10:10-10:45	孙剑（西安交通大学） 生成式人工智能：数学基础与交叉应用
10:45-11:20	孟德宇（西安交通大学） 新一代机器学习的数理基础问题
11:20-11:55	曾铁勇（北师大香港浸会大学） Effective Solutions to Robust Orthogonal Nonnegative Matrix

	Factorization via Oblique Manifold Transformation	
12:00-13:00	午 餐	地点：南开大学嘉园宾馆
2026年6月6日（星期六）下午		地点：陈省身数学研究所 216
主持人：常慧宾（天津师范大学）		
14:00-14:35	孔德兴（浙江大学） 数理医学智能体（线上）	
14:35-15:10	彭济根（广州大学） 视觉运动感知的生物似然数学理论与方法	
15:10-15:45	付树军（山东大学） 深度表征学习与医学图像应用	
15:45-15:55	茶 歇	
主持人：刘君（北京师范大学）		
15:55-16:30	李松（浙江大学） 低秩矩阵恢复与相位恢复的几个问题	
16:30-17:05	高卫国（复旦大学） Toward theoretical insights into diffusion trajectory distillation via operator merging	
主持人：王泽龙（国防科技大学）		
17:05-17:40	张小群（上海交通大学） Hierarchical Exact Solver for Large-scale Optimal Transport and its applications	
17:40-18:15	鲁坚（深圳大学） Wavelet-like-based methods for retrieving modes from non-stationary multicomponent signals	
18:25-20:00	晚 餐	地点：南开大学嘉园宾馆
2026年6月7日（星期日）上午		地点：陈省身数学研究所 216
主持人：段玉萍（北京师范大学）		

8:30-9:05	吴国宝 (Michael Ng) (香港浸会大学) Tensor Computations and Data Learning
9:05-9:40	董彬 (北京大学) AI for Mathematics: 从数学数字化到自动推理
9:40-10:15	黄忠亿 (清华大学) 基于低秩四元数矩阵恢复和深度图像先验的图像修复
10:15-10:25	茶 歇
主持人: 金正猛 (南京邮电大学)	
10:25-11:00	陈发来 (中国科学技术大学) 三维 CAD 模型的生成式建模
11:00-11:35	姚正安 (中山大学) 数字病理图像的建模计算及远程诊断
11:35-12:10	马坚伟 (哈尔滨工业大学) 面向学习场景的鲁棒目标函数设计: 迁移、联邦与带噪标签
12:15-13:15	午 餐 地点: 南开大学嘉园宾馆
青年学者报告 I	
2026 年 6 月 7 日 (星期日) 下午 地点: 陈省身数学研究所 216	
主持人: 薛运华 (南开大学)	
14:00-14:35	应时辉 (上海大学) TrimGOT: 基于部分图最优传输的域适应方法
14:35-15:10	郭志昌 (哈尔滨工业大学) 基于几何约束与多源信息融合的图像分割模型研究
15:10-15:45	王艳 (重庆师范大学) 基于多模态 AI 的儿童肺部异常诊断
15:45-15:55	茶 歇
主持人: 赵雨菲 (南开大学)	

15:55-16:30	韩欢（武汉理工大学） From black box to glass box: AMM-driven interpretable deep learning for simultaneous medical image registration and segmentation
16:30-17:05	邓良剑（电子科技大学） A General Deep Embedded Modelling Framework for Data Fusion
主持人：乐航睿（南开大学）	
17:05-17:40	刘俊（东北师范大学） 场景恢复的秩一先验及自监督学习方法
17:40-18:15	朱亚南（哈尔滨工业大学） 加速主对偶不动点算法
报告结束	
18:15-20:00	晚 餐 地点：南开大学嘉园宾馆

三维 CAD 模型的生成式建模

陈发来(中国科学技术大学)

Solving convolution-type integral equations with preconditioned neural operators

Raymond Honfu Chan(Lingnan University)

Abstract: Convolution-type integral equations arise from various fields, e.g., finite impulse response filters in signal processing and deblurring problems in image processing. When solving these equations, conventional numerical methods, like the multigrid method, can only efficiently solve the low-frequency components in the error, but not the high-frequency components. In this paper, we apply neural operators to address this issue. By adopting a preconditioning approach, we propose a novel training strategy that trains neural operators to solve the high-frequency components efficiently. Then, we combine the neural operators with some classical iterative solvers, like the weighted Jacobi method, to obtain an efficient hybrid iterative algorithm for the integral equations. We analyze the generalization error of our training strategy and the convergence of the hybrid iterative algorithm. We test our algorithms on large-scale and ill-conditioned linear systems discretized from one- and two-dimensional convolution-type integral equations. Our proposed algorithm significantly outperforms the multigrid method and the preconditioned conjugate gradient method in both iteration numbers and computational time.

A General Deep Embedded Modelling Framework for Data Fusion

邓良剑(电子科技大学)

Abstract: This talk primarily explores how to embed deep learning priors and traditional variational optimization model into a general modelling framework, which can effectively enhance the accuracy, generalizability, and interpretability of current intelligence methods. The talk mainly covers two aspects: 1) introducing the general embedded modelling framework, which bridges traditional variational optimization models and deep learning models; 2) giving some examples of the general embedded modelling framework, which are successfully applied to some representative data fusion tasks, also analyzing the relationship between these techniques and current mainstream deep learning approaches.

AI for Mathematics: 从数学数字化到自动推理

董彬(北京大学, 北京国际数学研究中心)

摘要: 人工智能正在为数学研究的推进带来新的可能性, “AI for Mathematics”(AI4Math) 也由此成为一个快速发展的交叉研究方向。本报告将首先探讨人工智能如何赋能数学研究的不同环节, 并回顾近年来 AI4Math 领域的若干代表性进展。在此基础上, 报告将引出一个核心主题: 数学形式化, 亦即以形式语言实现数学知识的数字化表达, 在提升人工智能数学推理能力方面发挥着关键作用。围绕这一主题, 报告将介绍北京大学 AI4Math 团队的整体研究规划, 以及团队在形式化模型与工具设计、自动推理系统构建和基准数据集建设等方面取得的阶段性成果。最后, 报告将进一步展望 AI4Math 的未来发展方向及其对数学研究范式可能产生的深远影响。

深度表征学习与医学图像应用

付树军(山东大学)

摘要: 图像恢复、增强与医学图像分割在深度学习的推动下取得了显著进展, 但在欠定问题、标注不足以及复杂结构分析等方面仍面临诸多挑战。本报告介绍我们在深度先验、特征建模与表征学习方面的研究工作。针对压缩感知图像恢复问题, 提出了一种深度先验引导的组稀疏表示模型, 有效融合全局结构信息与非局部自相似性。在显微成像任务中, 设计了视觉先验引导的自监督学习进行光照校正。在医学图像分析方面, 围绕表征学习与特征建模开展研究, 包括面向类别不平衡问题的对比学习方法、缺失模态条件下的表征优先融合策略, 以及兼顾语义信息与结构细节的分割模型与多尺度注意力网络。

Toward theoretical insights into diffusion trajectory distillation via operator merging

高卫国(复旦大学)

Abstract: Diffusion trajectory distillation accelerates sampling by training a student model to approximate the multistep denoising trajectories of a pretrained teacher model using far fewer steps. Despite strong empirical results, the tradeoff between distillation strategy and generative quality remains poorly understood. We provide a theoretical characterization by reinterpreting trajectory distillation as an operator merging problem, differentiating our analysis between two distinct regimes. In the linear Gaussian regime, where approximation error is zero, we isolate optimization error, specifically signal

shrinkage driven by finite training time, as the primary bottleneck. This characterization allows us to derive the theoretically optimal merging strategy, which exhibits a variance-driven phase transition and is computable via a Pareto dynamic programming algorithm. In the nonlinear Gaussian mixture regime, we prove that distilling composite steps incurs unavoidable approximation error due to the exponential growth of mixture components, and we quantify how these errors amplify across merges. Together, these results clarify the distinct theoretical mechanisms governing each regime and provide principled guidance for method selection. This is joint work with Ming Li.

基于几何约束与多源信息融合的图像分割模型研究

郭志昌(哈尔滨工业大学)

摘要: 报告围绕高阶几何建模、多源信息融合与交互式分割机制开展研究, 构建了一系列变分图像分割模型与数值方法。首先, 针对传统水平集模型依赖重初始化且界面演化稳定性不足的问题, 提出了一类基于分子束外延 (MBE) 方程的高阶几何变分分割模型。模型通过引入双调和扩散机制与斜率约束项, 实现了水平集函数的稳定演化与距离正则保持, 并结合 SAV 方法构建了无条件能量稳定的半隐式数值格式, 从而提高了复杂场景下界面传播的稳定性与鲁棒性。其次, 为提升复杂彩色纹理图像中的分割性能, 进一步提出了一种融合颜色与纹理信息的多线索分割模型。该模型结合非线性结构张量与区域统计特征, 利用高阶几何正则替代传统弧长项, 构建了无长度项的水平集演化框架, 实现了复杂纹理区域中的稳定界面演化与精细结构保持。最后, 针对复杂图像中用户先验信息难以充分利用的问题, 研究了交互式图像分割方法。通过引入用户交互约束与区域演化机制, 实现了用户引导下目标区域的精细分割, 进一步提高了模型在复杂边界与弱对比度场景中的适应能力。实验结果表明, 所提出的方法在多类自然图像与医学图像数据集上均取得了良好的分割效果, 在边界保持、抗噪性能以及复杂结构表达方面表现出较好的稳定性与鲁棒性。

From black box to glass box: AMM-driven interpretable deep learning for simultaneous medical image registration and segmentation

韩欢(武汉理工大学)

Abstract: Medical image registration and segmentation are two fundamental tasks in medical image analysis, which are often highly correlated and mutually beneficial in clinical applications. However, most existing methods either treat them as separate tasks or adopt black-box deep learning frameworks that lack mathematical interpretability and reliable physical constraints. To address these limitations, this paper proposes a mathematically interpretable joint segmentation and registration framework, which naturally unifies variational energy functionals, numerical optimization algorithms, and

deep learning network design. Each network module is endowed with clear physical meaning, effectively avoiding the uncertainty inherent in black-box models. Specifically, we design an alternating minimization method (AMM) iterative algorithm and rigorously prove its convergence, based on which we develop an AMM-driven interpretable deep learning method for simultaneous medical image registration and segmentation. Furthermore, we design specialized physical constraint modules, including the TVAct module for segmentation (to handle total variation regularization) and the LaplaceAct module for diffeomorphic registration (to handle Cauchy-Riemann constraint for diffeomorphic image registration). Theoretical results are provided to reveal the mechanism why the proposed neural network provides plausible solutions for segmentation and diffeomorphic registration.

基于低秩四元数矩阵恢复和深度图像先验的图像修复

黄忠亿(清华大学)

摘要: 针对现实彩色图像中可能存在的严重像素缺失和噪声污染问题, 我们提出了一种基于低秩四元数矩阵恢复和深度图像先验 (DIP) 方法的彩色图像修复技术——LRQMD 模型。应用矩阵精确恢复理论和神经正切核理论, 对该模型的修复能力进行了合理性和有效性分析; 设计了一种 ADMM 优化求解算法, 分析了算法的收敛性条件; 为提高算法的鲁棒性, 引入了基于热扩散方程构造的逆演化层 (IEL) 架构, 数值算例表明其显著提升了图像修复性能。

Advances in Self-Supervised Image Denoising: From Gaussian Noise to Real-World Noise

纪辉 (新加坡国立大学)

Abstract: Image denoising is a fundamental task in image restoration and a key component in solving inverse imaging problems. Deep learning has achieved remarkable success in denoising, particularly through supervised learning; however, its reliance on ground-truth images for network training limits its broader applicability in real-world scenarios. Recent research has increasingly shifted towards truth-free learning paradigms, where models are trained directly on noisy data without requiring clean references. In this talk, I will present a sequence of works on self-supervised image denoising, progressively addressing more complex noise models, from i.i.d. Gaussian noise to pixel-wise independent heteroscedastic noise, and ultimately to pixel-wise correlated noise observed in real-world data. Built upon data augmentation and mask-and-predict training strategies, our approaches enable networks to learn denoising solely from noisy observations. Experimental results demonstrate that the proposed self-supervised denoisers achieve performance.

数理医学智能体

孔德兴（浙江大学）

低秩矩阵恢复与相位恢复的几个问题

李松（浙江大学）

摘要：报告将介绍低秩矩阵恢复与相位恢复中的几个猜想与公开问题，特别侧重于报告人与合作者关于这些问题所做的几个工作。

场景恢复的秩一先验及自监督学习方法

刘俊（东北师范大学）

摘要：本报告聚焦不同天气与成像条件下的图像场景恢复问题，首先介绍一种实时场景恢复框架，将退化图像建模为清晰图像与一个秩一矩阵的叠加，利用秩一先验（ROP）开发出复杂度仅为 $O(N)$ 的快速算法，并在水下、沙尘及雾霾等多种条件下实现了高效、鲁棒的恢复效果。在该研究的基础上，针对真实世界图像去雾任务中基于先验的方法受限于手工假设、监督深度学习方法存在域偏移的问题，提出一种基于深度条件的自监督去雾方法。该方法将深度信息作为几何条件先验，嵌入透射图、大气光与清晰图像的联合优化中，有效结合了物理驱动模型的可解释性与自监督学习的灵活性。秩一先验侧重计算效率与通用退化模型，自监督模型强调在真实复杂雾霾场景中的去雾完整性与色彩保真度，促进了图像恢复技术在鲁棒性与适应性方面的发展。

Wavelet-like-based methods for retrieving modes from non-stationary multicomponent signals

鲁坚（深圳大学）

Abstract: In practical scenarios, most signals manifest as multi-component ones. To optimize the handling of such signals, a key step is to isolate the unknown constituent parts of the target multi-component signal from blind-source datasets. Empirical Mode Decomposition (EMD), first proposed by Norden Huang and his research team, breaks down a signal into a combination of intrinsic mode functions. EMD and its derivative techniques—such as Iterative Filtering Decomposition (IFD)—have found extensive use across diverse domains. Roughly ten years ago, Ingrid Daubechies and her collaborators developed the Synchrosqueezing Transform (SST), an effective and mathematically

rigorous approach for mode extraction. Nevertheless, EMD, IFD, SST, and their variants share a common constraint: they demand that signal components are clearly distinguishable in the time-frequency domain, which means their instantaneous frequencies (IFs) must not intersect. This limitation creates a major obstacle in numerous practical applications; for instance, in radar data analysis, multi-component signals often overlap

面向学习场景的鲁棒目标函数设计：迁移、联邦与带噪标签

马坚伟（哈尔滨工业大学）

新一代机器学习的数理基础问题

孟德宇（西安交通大学）

摘要：以深度学习/大模型为代表的机器学习方法与技术为当今科技领域的研究焦点。然而，相比技术水平的迅猛提升，机器学习基础理论研究进展远远滞后，大量技术经验发现无法找到理论支撑，以科学性为前提的学科大厦面临危局。重建机器学习理论体系已成为当今重大科技前沿问题。针对这一挑战，本报告将以深度学习的典型实验现象（智能涌现现象、鲁棒-精确悖论、幻觉与脆弱现象等）理论内涵作为分析对象，探讨未来机器学习理论可能发展的新型学习、统计与物理理论新框架。

高性能机织材料工业 CT 图像分割、重建与缺陷检测

聂梓伟（南京大学）

摘要：高性能机织材料在航空航天等领域有许多重要应用，但这类材料在制造成型后的内部结构探查与缺陷检测依赖工业 CT 图像的精准分割和重建。目前领域内这方面的公开数据集很少，相关的 AI 模型开发也不充分。为此，我们建立了一个机织材料工业 CT 图像的公开数据集，并在此基础上开发了材料中的经纬线分割与重建的 AI 模型，同时基于生成式人工智能方法建立了一个机织材料内部缺陷数据集并以此训练了相应的缺陷检测 AI 模型。我们进行了全面的数值实验并可视化展示了相关结果，验证了所开发的 AI 模型在分割精度、缺陷检测精度以及效率上都达到了当前最优的结果。

Path-wise Convergence Analysis of Diffusion Models for Image Generation

庞彤瑶（清华大学）

Abstract: We provide a path-wise convergence analysis of diffusion models for image generation through a localization. Our analysis shows how both the noise schedule and the choice of drift term in the forward diffusion model shape convergence behavior. This provides sharper theoretical guarantees and offers insights into the principled design of forward processes in diffusion-based image generation.

视觉运动感知的生物似然数学理论与方法

彭济根（广州大学）

多模态大模型与具身智能

彭亚新（上海大学）

生成式人工智能：数学基础与交叉应用

孙剑（西安交通大学）

摘要：生成式人工智能是当前通用人工智能发展的重要方向，主要通过设计人工智能算法实现对多模态、高维复杂样本分布的学习与新样本的生成，是当前人工智能应用于自动问答、跨模态生成、AI for science 等方法基础。生成式人工智能的底层基础是数学与统计学，本报告将介绍生成式人工智能的发展背景、数理原理及面临的挑战，重点阐述基于最优传输的可控与条件生成方法，并进一步介绍多模态与动态生成的基本方法及其在医学影像生成、多模态图文对齐、分子结构生成等任务中的应用。最后，报告总结并展望生成式 AI 未来发展前景，着重关注数学方法驱动的生成式人工智能在科学研究与交叉应用中的潜力。

基于多模态 AI 的儿童肺部异常诊断

王艳（重庆师范大学）

摘要：儿童肺部疾病是全球儿科发病率与死亡率最高的疾病之一，且具有发病急、进展快、易引发多器官衰竭的特点。现有的辅助诊断方法大多还是照搬成人影像的处理思路，并没有专门针对儿童特有的解剖结构去做相应的适配，而且往往依赖专家级异常标注数据，难以满足真实临床需求。本报告介绍基于自编码器与归一化流的无监督检测模型 AE-SE-FLOW，以及基于改进 MedCLIP 框架和大模型微调技术

的医疗图文互答系统。

Variational Bayesian Inference for Tensor Robust Principal Component Analysis

文有为(湖南师范大学)

Abstract: Tensor Robust Principal Component Analysis (TRPCA) holds a crucial position in machine learning and computer vision. It aims to recover underlying low-rank structures and characterizing the sparse structures of noise. Current approaches often encounter difficulties in accurately capturing the low-rank properties of tensors and balancing the trade-off between low-rank and sparse components, especially in a mixed-noise scenario. To address these challenges, we introduce a Bayesian framework for TRPCA, which integrates a low-rank tensor nuclear norm prior and a generalized sparsity-inducing prior. By embedding the priors within the Bayesian framework, our method can automatically determine the optimal tensor nuclear norm and achieve a balance between the nuclear norm and sparse components. Furthermore, our method can be efficiently extended to the weighted tensor nuclear norm model. Experiments conducted on synthetic and real-world datasets demonstrate the effectiveness and superiority of our method compared to state-of-the-art approaches.

Tensor Computations and Data Learning

吴国宝(香港浸会大学)

Abstract: In this talk, I share my results in tensor decompositions, hypergraph learning, and data fusion applications. Both theoretical and numerical results are presented for demonstration and discussion.

数字病理图像的建模计算及远程诊断

姚正安(中山大学)

摘要: 病理诊断是肿瘤诊断、分型、疗效评估和预后判断的重要依据。数字化病理的发展提高了医生的效率，但病理图像的超大尺度和成像质量成为了智能辅助分析、跨中心交流和远程病理诊断的瓶颈。现有的相关研究多从工程角度出发，基于数据模型和结果导向，缺乏临床可信、可解释的数学模型。围绕数字病理图像的建模计算与远程诊断，我们构建了一套基于病理先验的数学物理模型，系统研究病理图像标准化、大尺度演化计算、乳腺癌免疫微环境量化以及远程病理中的压缩与传输问题。

TrimGOT: 基于部分图最优传输的域适应方法

应时辉(上海大学)

摘要: 本报告围绕在实际域适应任务中源域与目标域不完全匹配问题展开。相较传统最优传输方法所依赖的完全质量传输假设,我们提出一种基于图的跨域部分对齐框架(TrimGOT)。该框架在特征分布对齐基础上,联合建模节点特征与图结构信息,显式刻画局部相似性与类一致性结构。进一步,设计动态裁剪策略,在每次传输计算前自动识别并移除无关节点,避免不可靠映射;同时以数据驱动方式引入自适应保留比例机制,兼顾了算法鲁棒性与结构完整性。理论方面,给出了收敛性分析及误差上界估计。在多个基准数据集上的大量实验表明,TrimGOT 在对齐精度与下游分类性能上均显著优于现有方法。

A Normalized Parametrization of Accelerated Gradient Flows and Structure-Preserving Discretizations

袁景(浙江师范大学)

Abstract: We study a normalized parametrization of accelerated gradient flows for convex optimization. The parametrization introduces a scaling parameter $\alpha > 0$ that makes the interaction between time scaling, damping, Lyapunov dissipation, and discrete stability explicit. In continuous time, the normalized flow admits a Lyapunov decay estimate with rate $e^{-\alpha t}$. Based on this normalized formulation, we derive a family of structure-preserving discretizations, including implicit, semi-implicit, predictor-corrector, and gradient-corrected schemes. We further extend the framework to composite optimization and propose velocity-based proximal splitting schemes, in which the proximal operator is applied to a velocity-related variable before recovering the position update through the flow relation. Finally, numerical experiments on representative test problems illustrate the effect of α on convergence behavior.

Effective Solutions to Robust Orthogonal Nonnegative Matrix Factorization via Oblique Manifold Transformation

曾铁勇(北师大香港浸会大学)

Abstract: In this talk, we address the problem of robust orthogonal nonnegative matrix factorization (RONMF), a crucial challenge in data analysis. We first propose a RONMF model that explicitly handles both dense and sparse noise, making it suitable for a wide

range of real-world applications. To circumvent the computational complexity associated with the Stiefel manifold and effectively solve the proposed model, we introduce an exact penalty method that transforms the optimization problem from the Stiefel manifold to the Oblique manifold. To achieve this, we develop the EP-RONMF algorithm, which seeks a point satisfying the weak second-order optimality conditions through an alternating proximal method and iterative updates of the penalty parameter. This approach successfully addresses the nonconvex nature of the ONMF problem and ensures convergence to a stable solution. To validate the efficacy of our method, we conducted extensive experiments on diverse datasets, including image, text, and hyperspectral data. The results clearly demonstrate the superiority of our approach compared to existing techniques.

Learning Explicitly-Driven Unsupervised Frameworks for Variational Deformable Image Registration

张建平(湘潭大学)

Abstract: Although existing unsupervised medical image registration frameworks are computationally efficient, they are largely limited by implicit regression-based formulations. Because they infer deformations via black-box feature concatenation, they do not incorporate an explicit displacement-indexed matching mechanism. To overcome this, we introduce registration frameworks inspired by classical variational models, in which the matching process is explicitly driven by a velocity field or a Betrami coefficient. Extensive experiments on brain MRI (OA SIS, IXI) and abdominal CT (LiTS) datasets demonstrate that the proposed methods effectively disentangle complex, heterogeneous deformations, achieving state-of-the-art accuracy, strong generalization capability, and high inference efficiency, all under strong topology-preserving regularization.

Hierarchical Exact Solver for Large-scale Optimal Transport and its applications

张小群(上海交通大学)

Abstract: Optimal transport (OT) underlies many machine-learning and computer-vision tasks, yet solving large-scale OT problems under a tight memory budget remains challenging because of an inherent trilemma among precision, memory efficiency and dimensional scalability. To resolve this trade-off we propose a memory-efficient, dimension-scalable hierarchical exact solver for large-scale OT with low-rank cost. The proposed algorithm is a multi-resolution decomposition of the OT

problem coupled with parallel-friendly linear-programming solvers. To guarantee memory efficiency we strictly bound the storage to linear complexity via active support pruning. Theoretically, we prove a scale-independent iteration-complexity upper bound for the refinement phase (consistent with the empirical observation) and show that, under standard assumptions, the algorithm converges to the global optimum. Numerical experiments demonstrate the scalability and exactness of the proposed algorithm across a wide range of regimes. The algorithm is capable to handle million-scale problems in very high dimensions ($n=106$, $d=8192$) on a single GPU, while still delivering exact solutions on synthetic high-dimensional data. The method thus alleviates the memory and scalability bottlenecks of existing solvers and resolves the precision-memory-dimensionality trilemma for large-scale OT.

Pretrained Transform-Based Tensor Representations

赵熙乐(电子科技大学)

Abstract: Recently, Fourier transform-based tensor representations have been suggested for processing and analyzing multi-dimensional data arising from real-world applications, where transform and the corresponding latent tensor serve as the two building blocks of this framework. From both perspectives, this talk will review recent progress in transform-based tensor representations. On one hand, we will discuss the evolution of the transform from linear and shallow ones to nonlinear and deep ones. On the other hand, we will discuss the evolution of the corresponding latent tensor from shallow and untrained ones to deep and pretrained ones. Finally, we will also discuss the limitations and future possibilities of the transform-based tensor representation.

加速主对偶不动点算法

朱亚南(哈尔滨工业大学)

摘要: 本报告提出一种加速主对偶不动点方法 (Accelerated Primal - Dual Fixed Point, APDFP), 用于求解含非光滑项及线性算子复合结构的复合优化问题。此类问题广泛存在于机器学习、信号处理和医学成像等领域的数学模型中, 例如稀疏正则化分类、图引导数据分析以及 CT 图像重建等。所提出的 APDFP 方法基于 Nesterov 加速思想, 具有完全解耦的迭代结构, 可视为 Nesterov 第二加速方法在线性算子不再为恒等映射情形下的自然推广。理论上, 我们将部分主对偶间隙 (partial primal - dual gap) 的收敛速率相对于梯度 Lipschitz 常数关于迭代数 k 由 $1/k$ 提升至 $1/k^2$ 。数值实验方面, 在图引导逻辑回归和 CT 图像重建问题上的测试结果表明, 该方法具有良好的正确性与计算效率。

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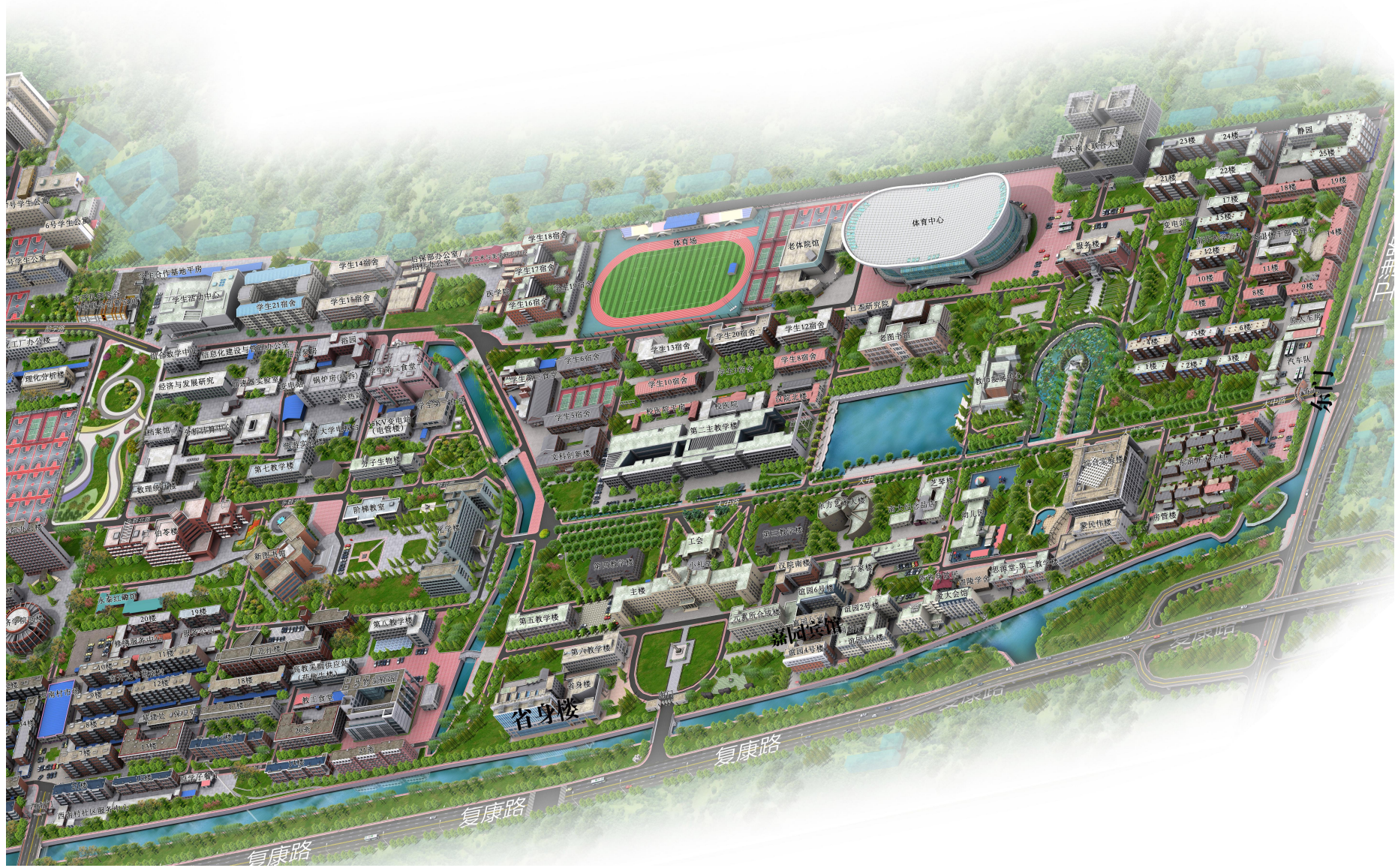
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