天元数学国际交流中心
Tianyuan Mathematics Research Center

模型、数据与知识驱动的优化反演问题研讨会

Workshop on Model/Data/Knowledge-Driven Optimization and Inversion

TY-2026-C-061

会议手册

Conference Program

召集人： **Organizers：**

姓名：张晔 深圳北理莫斯科大学

姓名：韩丛英 中国科学院大学

2026 年 9 月 20 日—24 日

日期英文, 2026

中国·昆明

Kunming, China

天元数学国际交流中心简介

天元数学国际交流中心（以下简称“中心”）成立于2023年7月，由中国科学院、国家自然科学基金委员会、中国数学会、中国科学院数学与系统科学研究院，以及昆明市有关部门共同支持建设的数学与交叉科学交流机构。旨在搭建数学及其跨学科应用领域的学术交流平台，提升我国数学整体研究水平，成为国际一流的数学交流与合作研究中心。

中心位于昆明市宜良县柴石滩水库库区，三面环山、一面临水，环境优美，海拔约1700米。距长水国际机场约90公里（车程约1.5小时），距石林风景区约30公里，距九乡风景区约20公里。

中心总建筑面积约6000平方米，设有大报告厅（可容纳100人，配备高清LED屏）、中型会议室1间、小型会议室4间、研讨/工作室21间、图书阅览室1间、咖啡厅1间。专家楼配有56间宿舍及自助洗衣房、公共休息区等配套设施。

中心官方网站：http://tianyuan.amss.ac.cn/

Introduction to Tianyuan Mathematics Research Center（TYMRC）

The Tianyuan Mathematics Research Center (established in July 2023) is jointly supported by the Chinese Academy of Sciences, the National Natural Science Foundation of China, the Chinese Mathematical Society, the Academy of Mathematics and Systems Science of the Chinese Academy of Sciences, and relevant departments of Kunming City. It aims to build a platform for academic exchange in mathematics and interdisciplinary applications, enhance China's overall mathematical research level, and become a world-class center for mathematical exchange and collaborative research.

It is located in the national-level public welfare forest in the Chaishitan Reservoir area of Yiliang, Kunming, Yunnan Province, surrounded by mountains on three sides and facing water on one side. The center has a total land area of about 27,000 square meters, with three two-story main buildings, namely the Research Building, the Expert Building and the Logistics Building, which can accommodate nearly 200 people for academic activities, and are equipped with a library and reading room, a restaurant and a certain number of offices and guest rooms.

The center has a total construction area of approximately 6,000 square meters. It features a main lecture hall (capacity: 100 people, equipped with an HD LED screen), one medium-sized seminar room, four small meeting rooms, 21 seminar/workshop rooms, one library and reading room, and one café. The Expert Building is equipped with 56 guest rooms, as well as supporting facilities such as a self-service laundry room and a public lounge.

Official website: http://tianyuan.amss.ac.cn/

会议信息

一、研讨主题、内容及意义：

本交流研讨项目的主题是“模型、数据与知识驱动的优化反演问题”。

反演问题本质上是一个优化问题，即通过数学优化算法求解数学物理模型获得该问题的最优解。反问题在整个自然科学领域具有特殊重要性，它是数学、物理、化学、地学、生物学、金融、商业、生命科学、计算技术与工程相关的交叉学科。比如近几年，涉及反问题领域的学科得到了迅速的发展：定量遥感科学反问题、国防工业反问题、大气物理反问题、天体物理反问题、医学图像处理反问题、计量经济领域中的参数识别反问题、股票金融科学中的反问题、生命科学中的反问题、信息科学反问题、地球化学反问题、高能物理中的光能谱反问题、材料固有频率寻找金属孔洞的反问题、光学反问题、地球物理勘探反问题、大数据与人工智能等。

反问题一般指的是利用实际观测数据来推断被调查系统的参数/模型的特征。 这通常需要求解一个线性或非线性系统，来获得对待求参数/模型的估计。数学问题的适定性条件：1) 解是存在的；2) 解是唯一的；3) 解是稳定的。反之，若上述三个条件中，至少有一个不能满足，则称其为不适定的。反问题通常是不适定的，即给定问题解未必存在；解未必唯一；以及解的连续性/稳定性不一定能够保证。

传统的反问题的数值解法且至今仍然广泛沿用的是 Tikhonov 变分正则化方法及其各种变形，该方法最初是在泛函空间考虑的。Tikhonov 正则化方法可以解决当解的唯一性成立而稳定性和存在性不成立而引起的不适定问题并以一族相邻近的适定问题的解去逼近原问题的。非线性反问题的数值解法除了 Tikhonov 变分正则化方法及变种外，另一类重要的方法就是最优化方法，比如信赖域优化方法、正则化 Gauss-Newton 法、混合 Newton-Tikhonov 方法，Frozen-Landweber 迭代法、Newton-Landweber 型迭代法等。此外，结合压

缩感知思想，稀疏优化方法在稀疏信号处理，压缩重构等领域也得到了广泛的应用。

机器学习算法用来求解一类特殊的数据科学中的反问题，比如数据降维和信息挖掘其中涉及到多种优化问题：一些涉及凸优化问题，例如，逻辑回归或支持向量机；一些涉及高度非线性和非凸优化问题，例如深度神经网络。为了适应日趋庞大的数据量以及计算量，国内外学者不断对随机优化算法和批量算法进行改进，并提出新的方法。一些学者从提高收敛速度出发，力图将优化方法的收敛速度由此线性改进到线性收敛；一些学者从问题本身出发，试图克服问题的高度非线性和病态性。一方面，为了提高机器学习算法中优化问题的收敛速度，学者从不同角度给出了不同的解决方案。

在机器学习的最优化过程中，最突出的挑战是问题的病态性。在深度神经网络中尤为明显，病态体现在随机梯度下降会“卡”在某些情况，此时即使很小的更新步长也会增加代价函数。并且尽管机器学习的很多方法都存在病态问题，但是有些适用于其他情况的解决病态的技术并不适用于神经网络。例如，牛顿法在解决带有病态条件的 Hessian 矩阵的凸优化问题时，是一个非常优秀的工具，但针对神经网络的优化问题时牛顿法还需要进行很大的改动。

深度学习面临的大多都是非凸优化问题，对于非凸函数时，有可能会存在多个局部极小值。事实上，几乎所有的深度模型都会有非常多的局部极小值，并且这些局部极小值并非是非凸性带来的问题。由于深度神经网络的模型不可辨识性，使得神经网络代价函数具有非常多、甚至不可数无限多的局部极小值，且这些极小值具有相同的代价函数值，使得深度模型的局部极小值问题更为复杂。

高性能计算及应用是近年来科学界与企业界的研究热点。大量的应用问题数值求解，往涉及海量的数据分析和矩阵操作，对算力的要求极高，所以一直是高性能计算领域的一大挑战。作为科技创新的基本工具之一，高性能计算为科学研究与技术应用提供必不可少的算力保障，广泛应用于油气勘探、气象分析、灾害预报、宇宙探索、材料/药物设计等众多领域。传统的超级计算机主要依赖于大规

模集成电路技术。然而，由于摩尔定律的限制，集成电路可容纳的晶体管数目已接近饱和，从而极大地限制了超算算力的进一步提升。此外，超级计算机的高能耗及其导致的温室气体排放也是技术发展的重大瓶颈。以目前国内最快的超算“神威·太湖之光”为例，其一年的用电量达到 15 兆瓦 (https://www.top500.org)。因此，世界各国亟需能够克服这些瓶颈的下 一代高性能计算技术。

本交流研讨项目邀请了国内外本领域及学科交叉领域的优秀专家学者，就交叉学科领域的反问题理论、最优化方法、数据统计分析、机器学习及人工智能方法从多维度展开分析研讨，力争给出学科或学科方向的发展的建议。

契合 “模型、数据与知识驱动的优化反演问题”这个主题，本交流项目的研讨内容包括但不限于一下几个方面：

(1) 不适定反问题最新进展

内容涵盖模型驱动的反问题、数据驱动的反问题

(2) 正则化理论及算法最新进展

(3) 最优化理论及算法

(4) 非标准正则化方法最新进展

(5) 地球物理反问题

(6) 大数据与机器学习

(7) 高性能计算最新进展

(8) 科学工程的其它应用进展

二、活动日程：

报到：2026 年 9 月 20 日

报告：2026 年 9 月 21 日至 9 月 23 日

离会：2026 年 9 月 24 日

地点：天元数学国际交流中心（云南省昆明市宜良县柴石滩水库）

三、相关事项：

1. 本次研讨会得到天元数学国际交流中心资助，参会人员的住宿及餐饮由中心承担，其余费用（含往返交通费）由参会人员自理。
2. 中心统一安排往返昆明高铁站/长水机场及昆明市区的接送服务。请及时登录项目管理系统（http://tianyuanpm.amss.ac.cn/）登记行程信息。
3. 中心距离医院较远，建议访客适当随时携带一些必备药品。
4. **会议联系人：**
   张晔（深圳北理莫斯科大学）：电话；15889646521

Conference Information

I. Seminar Theme, Content, and Significance：

This seminar focuses on “model-, data- and knowledge-driven optimized inversion problems”. Essentially, inversion problems can be formulated as optimization problems, in which optimal solutions of mathematical and physical models are obtained via mathematical optimization algorithms. As a typical interdisciplinary research direction, inversion problems play a vital role in natural sciences, covering mathematics, physics, chemistry, geoscience, biology, finance, business, life sciences, computational technology and engineering. In recent years, inversion-related disciplines have achieved rapid development, including quantitative remote sensing inversion, national defense industrial inversion, atmospheric physics inversion, astrophysical inversion, medical image processing inversion, parameter identification in econometrics, stock and financial inversion, life science inversion, information science inversion, geochemical inversion, optical spectral inversion in high-energy physics, metal defect detection via inherent frequency analysis of materials, optical inversion, geophysical exploration inversion, and big data and artificial intelligence-based inversion technologies.

In general, inversion problems aim to infer the parameters and structural characteristics of an unknown system from practical observational data. This commonly requires solving linear or nonlinear systems to achieve reliable estimation of undetermined parameters and model characteristics. A well-posed mathematical problem satisfies three classical conditions: existence, uniqueness, and stability of the solution. A problem is regarded as ill-posed if any of the three conditions fails to hold. Most inversion problems are inherently ill-posed, meaning that solutions may be non-existent, non-unique, or numerically unstable with respect to observational perturbations.

The Tikhonov variational regularization method and its variants have long been the most widely adopted numerical approaches for solving inversion problems, originally developed within the framework of functional spaces. This family of methods effectively addresses ill-posedness induced by the absence of solution existence and stability while preserving solution uniqueness, and approximates the original ill-posed problem using a sequence of neighboring well-posed subproblems. Beyond Tikhonov-type regularization, optimization-based methods constitute another essential category of numerical solvers for nonlinear inversion problems, including trust-region optimization, regularized Gauss – Newton methods, hybrid Newton – Tikhonov schemes, Frozen-Landweber iteration, and Newton – Landweber-type iterative algorithms. Furthermore, combined with compressed sensing theories, sparse optimization techniques have been extensively applied in sparse signal processing and compressive reconstruction tasks.

Machine learning algorithms provide novel solutions for data-driven inversion problems in data science, including dimensionality reduction and information mining, which involve various optimization paradigms. Some learning tasks correspond to convex optimization problems, such as logistic regression and support vector machines, while deep neural networks typically involve highly nonlinear and non-convex optimization formulations. To accommodate the explosive growth of data scale and computational demands, researchers worldwide have continuously improved stochastic optimization and batch optimization algorithms. Relevant studies mainly follow two technical routes: accelerating the convergence rate of optimization algorithms from linear convergence to higher-order convergence, and mitigating the strong nonlinearity and ill-posedness inherent in practical inversion problems, so as to enhance the optimization performance of machine learning models.

Ill-posedness is the most prominent challenge in machine learning optimization, especially for deep neural networks. In stochastic gradient descent optimization, ill-posedness often leads to stagnation, where even extremely small learning rates fail to reduce the loss function. Although ill-posedness widely exists in machine learning optimization, conventional regularization techniques for ill-conditioned problems are not fully applicable to neural network training. For instance, the Newton method is effective for solving convex optimization problems with ill-conditioned Hessian matrices, yet substantial modifications are required to adapt it to deep learning optimization scenarios.

Most deep learning tasks correspond to non-convex optimization problems with multiple local minima. Nearly all deep learning models suffer from massive local minima, which are not merely attributed to non-convexity. Due to the unidentifiability of deep neural network structures, the loss function possesses numerous, even countlessly infinite, local minima with identical loss values, which further complicates the local minimum optimization problem of deep models.

High-performance computing (HPC) and its applications have become a prevailing research hotspot in academia and industry. Numerical solutions to large-scale practical problems involve massive data analysis and matrix operations, imposing extremely high computational requirements and posing long-standing challenges for HPC research. As a fundamental support for technological innovation, HPC provides indispensable computational power for scientific research and industrial applications, and has been widely deployed in oil and gas exploration, meteorological analysis, disaster prediction, aerospace exploration, material and drug design, and many other fields.

Traditional supercomputers rely heavily on large-scale integrated circuit technology. However, constrained by Moore’s Law, the density of transistors on integrated circuits has approached its physical limit, severely restricting the further improvement of supercomputing performance. In addition, the excessive energy consumption and corresponding carbon emissions of supercomputers have become critical bottlenecks for industrial and technological development. For example, Sunway TaihuLight, once the fastest supercomputer in China, consumes approximately 15 megawatts of power annually (TOP500 official data, 2026). Therefore, next-generation high-performance computing technologies are urgently needed worldwide to break through the above limitations.

This seminar brings together distinguished domestic and international experts in related and interdisciplinary fields to conduct in-depth discussions on inversion theory, optimization methods, statistical data analysis, machine learning and artificial intelligence technologies, aiming to provide developmental suggestions for relevant interdisciplinary research directions.

Centering on the theme of “model-, data- and knowledge-driven optimized inversion problems”, the seminar covers the following research topics (but not limited to):

(1) Recent advances in ill-posed inversion problems, including model-driven and data-driven inversion frameworks;

(2) State-of-the-art progress in regularization theories and algorithms;

(3) Advanced optimization theories and numerical algorithms;

(4) Latest developments in non-standard regularization methods;

(5) Theoretical and applied progress in geophysical inversion;

(6) Big data analysis and machine learning for inversion problems;

(7) Cutting-edge advances in high-performance computing technologies;

(8) Innovative applications of inversion methods in scientific and engineering fields.

II、Program Schedule：

Check-in: September 20, 2026

Talks: September 21 － 23, 2026

Departure: September 24, 2026

Venue: Tianyuan Mathematics Research Center (Chishitan Reservoir, Yiliang County, Kunming, Yunnan Province)

III、Practical Information：

1. This seminar is financially supported by the TYMRC. Accommodation and meals for participants will be covered by the Center. All other expenses (including round-trip transportation) shall be borne by the participants themselves.
2. The Center will arrange shuttle services to/from the following locations: Kunming High-Speed Railway Station, Kunming Changshui International Airport, and downtown Kunming. Participants are kindly requested to log in to the project management system (http://tianyuanpm.amss.ac.cn/) in a timely manner to register their travel information.
3. As the Center is located at a considerable distance from the nearest hospital, participants are advised to bring an adequate supply of essential personal medications.
4. Conference Contact:
   Ye Zhang (Shenzhen MSU-BIT University): Phone Number: 15889646521

会议日程一（Schedule I）

9 月 20-日	
周日 Sunday	报到（Registration）
9 月 24 日	
周四 Thursday	离会（Departure）

9 月 21 日（周一 Monday）			
9:10-9:30	开幕式及合影 Opening Ceremony & Group Photo Prof. Yanfei Wang		
时间 Time	报告人 Speaker	题目 Title of talk	主持人 Chair
9:30-10:00	Gen Nakamura Hokkaido University	Inversion Analysis for Inverse Clustered Eigenvalues Problems and Its Other Application	Yanfei Wang UCAS
10:00-10:30	Hui Liang HIT (Shenzhen)	Compatibility of Collocation Error Analyses for Volterra Integral Equations with Smooth and Weakly Singular Kernels	
10:30-11:00	讨论（Discussion over coffee）		
11:00-11:30	Haibin Wang Southeast University	Recent Advances in an Inverse Boundary Value Problem for the Heat Equation	Qinglong He Guizhou University
11:30-13:00	午餐（Lunch Break）		
15:00-15:30	Congying Han UCAS	Greedy algorithms for stochastic monotone k-submodular maximization under full-bandit feedback	Yubin Tian SMBU
15:30-16:00	Qinglong He Guizhou University	Truncated trust region method for nonlinear inverse problems and application in full-waveform inversion	
16:00-16:30	讨论（Discussion over coffee）		
16:30-17:00	Hongyu Liu CityU	Inverse boundary problems with a single passive observation	Sergey Kabanikhin NSU
17:00-17:30	Ye Zhang SMBU	Neural network yields regularization for ill-posed inverse problems	
17:30-19:00	晚餐（Dinner Break）		

会议日程二（Schedule II）

9月22日（周二 Tuesday）			
时间 Time	报告人 Speaker	题目 Title of talk	主持人 Chair
9:00-9:30	Sergey Kabanikhin Novosibirsk State University	Continuation problems: Theory, numerics, neural networks and applications	Hongyu Liu CityU
9:30-10:00	Sidorov Denis Harbin Institute of Technology	Volterra models of hereditarian nonlinear dynamical systems	
10:00-10:30	讨论（Discussion over coffee）		
11:00-11:30	Ziyan Luo Beijing Jiaotong University	Semismooth Newton method for sparse QCQP	Liping Wang NUAA
11:30-13:00	午餐（Lunch Break）		
14:00-17:30	讨论（Discussion over coffee）		
17:30-19:00	晚餐（Dinner Break）		

会议日程三（Schedule III）

9月23日（周三 Wednesday）			
时间 Time	报告人 Speaker	题目 Title of talk	主持人 Chair
9:00-9:30	Liping Wang Nanjing University of Aeronautics and Astronautics	A Unified Algorithm for Nonconvex Decentralized Nonlinear Optimization	Congying Han UCAS
9:30-10:00	Ruxin Wang Shenzhen Institutes of Advanced Technology, CAS	Unwrapping Visual Black-box Models by Interaction Decomposition	

<table>
<tr><td>10:00-10:30</td><td colspan="3">讨论（Discussion over coffee）</td></tr>
<tr><td>11:00-11:30</td><td>Ovanes Petrosian
Shenzhen MSU-BIT University</td><td>LABO: Latent-free Adaptive Binary Optimizer for Binary Neural Networks</td><td>Gen Nakamura
Hokkaido University</td></tr>
<tr><td>11:30-13:00</td><td colspan="3">午餐（Lunch Break）</td></tr>
<tr><td>15:00-15:30</td><td>Jianfeng Zhang
Zhejiang Normal University</td><td>Global-Pixel-RRT: An automatic global extraction algorithm for liver vascular system</td><td rowspan="2">Ovanes Petrosian
SMBU</td></tr>
<tr><td>15:30-16:00</td><td>Zhengyu Zhao
Shandong University of Technology</td><td>Fast Numerical Derivatives Based on Multi-interval Fourier Extension</td></tr>
<tr><td>16:00-16:30</td><td colspan="3">讨论（Discussion over coffee）</td></tr>
<tr><td>16:30-17:00</td><td>Jianxun Yang
SMBU</td><td>Computation and Root Certification of Rayleigh-Wave Dispersion Spectra Based on Multilayer Depth Impedance and the Evans Function</td><td rowspan="2">Ye Zhang
SMBU</td></tr>
<tr><td>17:00-17:30</td><td>Yanfei Wang
UCAS</td><td>Closing Remarks</td></tr>
<tr><td>17:30-19:00</td><td colspan="3">晚餐（Dinner Break）</td></tr>
</table>

报告摘要（Report Abstracts）

1. 报告题目 Title：Inversion Analysis for Inverse Clustered Eigenvalues Problems and Its Other Application

   报告人 Speaker：Gen Nakamura（Hokkaido University）

   报告摘要 Abstract：Many materials around us have viscoelastic properties under strain or stress. How to model them, measure them, and identify them are major questions. In this talk, modeling viscoelastic materials by spring-dashpot models, we consider inverse problems of recovering unknown parameters inside the models from the measured data. The data we use is either spectral data or a rheometer-measured data. More precisely, for the spectral data, we use the so-called clustered eigenvalues, and for the rheometer-measured data, we use an input-output relation giving a torque as an input and the corresponding displacement as an out put. You will see that for the both different types of data, the associated inverse problems reduce to determining a polynomial from its roots.

   References:

   1) S. Chen, M. de Hoop, Y. Deng, C-L. Lin, G. Nakamura, Clustered eigenvalue problem for glassy state relaxation and its inverse problem, SIAM Journal on Applied Math., 86 (2026), 1058-1075.

   2) S. Chen, M. de Hoop, Y. Deng, C-L. Lin, G. Nakamura, Inverse spectral problem for glassy state relaxation approximated by Prony series, Applied Mathematics Ltters, 178 (2026), Article 109904.

   3) Y. Deng, C-L. Lin, G. Nakamura, Explicit form of relaxation tensor for isotropic extended Burgers model and its spectral inversion, arXiv:2602.10636.

2. 报告题目 Title：Compatibility of Collocation Error Analyses for Volterra Integral Equations with Smooth and Weakly Singular Kernels

   报告人 Speaker：Hui Liang（Harbin Institute of Technology, Shenzhen）

   报告摘要 Abstract：The numerical solution by piecewise polynomial collocation and iterated collocation of Volterra integral equations (VIEs) of the second kind has been extensively studied and apparently sharp convergence results are known for the cases of a smooth kernel $K(t,s)$ and a weakly singular kernel $(t-s)^{-\alpha}K(t,s)$, where $\alpha\in(0,1)$ is a parameter. If one takes the formal limit as $\alpha\to 0$, then the weakly singular VIE reduces to the smooth VIE, but the known collocation error bounds for the weakly singular VIE do not become the collocation error bounds for the smooth VIE --- the error bounds for the smooth VIE are typically of a higher order. In the lecture course, this anomaly is explained and new sharper collocation and iterated collocation error bounds are derived for the weakly singular VIE that blend exactly as $\alpha\to 0$ with known error bounds for the smooth VIE. This analysis is substantially different from previous VIE collocation analyses, e.g., it constructs a remarkable new decomposition of the solution of the weakly singular VIE, it investigates in detail the dependence on α of the matrices associated with collocation, it establishes a new Gronwall inequality.

3. 报告题目 Title：Recent Advances in an Inverse Boundary Value Problem for the Heat Equation

报告人 Speaker：Haibin Wang（Southeast University）

报告摘要 Abstract：In this talk, we consider an inverse boundary value problem for the heat equation, where the aim is to reconstruct unknown defects-such as cavities, inclusions, and cracks-inside a diffusive medium from boundary measurements. We will present our recent results on sampling-type methods for numerically recovering the locations and geometric features of these defects. The mathematical principles underlying the proposed reconstruction methods will also be discussed.

4. 报告题目 Title：Greedy algorithms for stochastic monotone k-submodular maximization under full-bandit feedback

报告人 Speaker：Congying Han（University of Chinese Academy of Sciences）

报告摘要 Abstract：In this work, we theoretically study the Combinatorial Multi-Armed Bandit problem with stochastic monotone k-submodular reward function under full-bandit feedback. In this setting, the decision-maker is allowed to select a super arm composed of multiple base arms in each round and then receives its k-submodular reward. The k-submodularity enriches the application scenarios of the problem we consider in contexts characterized by diverse options. We present two simple greedy algorithms for two budget constraints (total size and individual size) and provide the theoretical analysis for upper bound of the regret value. For the total size budget, the proposed algorithm achieves a 1/2-regret upper bound by $\tilde{O}\left(T^{\frac{2}{3}}(kn)^{\frac{1}{3}}B\right)$ where T is the time horizon, n is the number of base arms and B denotes the budget. For the individual size budget, the proposed algorithm achieves a 1/3-regret with the same upper bound. Moreover, we conduct numerical experiments on these two algorithms to empirically demonstrate the effectiveness.

5. 报告题目 Title：Truncated trust region method for nonlinear inverse problems and application in full-waveform inversion

报告人 Speaker：Qinglong He（Guizhou University）

报告摘要 Abstract：We present a general truncated trust region method to solve large-scale nonlinear inverse problems. The truncated trust region method can serve as an implicit regularization method, and it can take advantage of the second-order derivative information of the misfit functional. The convergence of the truncated trust region method is provided under some smoothness assumptions. To improve the computational efficiency and reduce the memory requirement, we develop a second-order adjoint-state method to efficiently estimate matrix – vector products, and solve the trust region subproblem using the truncated conjugate gradient method with the matrix-free strategy. The full-waveform inversion problem is used to test the numerical performance of the proposed method. Numerical results show that the truncated trust region method can perform better than conventional methods (e.g. nonlinear conjugate gradient method and L-BFGS) for highly nonlinear inverse problems, in terms of inverting resolution.

6. 报告题目 Title：Neural network yields regularization for ill-posed inverse problems

报告人 Speaker：Ye Zhang（Shenzhen MSU-BIT University）

报告摘要 Abstract：In this talk, we establish universal approximation theorems for neural networks applied to general nonlinear ill-posed operator equations. In addition to the approximation error, the measurement error is also taken into account in our error estimation. We introduce the expanding neural network method as a novel iterative regularization scheme and prove its regularization properties under different a priori assumptions about the exact solutions. Within this framework, the number of neurons serves as both the regularization parameter and iteration number. We demonstrate that for data with high noise levels, a small network architecture is sufficient to obtain a stable solution, whereas a larger architecture may compromise stability due to overfitting. Furthermore, under standard assumptions in regularization theory, we derive convergence rate results for neural networks in the context of variational regularization. Several numerical examples are presented to illustrate the robustness of the proposed neural network-based algorithms.

7. 报告题目 Title：Inverse boundary problems with a single passive observation

报告人 Speaker：Hongyu Liu（City University of Hong Kong）

报告摘要 Abstract：This talk presents our recent progress in solving inverse boundary problems using only a single passive observation. The key to this result is a suite of new technical tools, chief among them a dimensional reduction technique (either parametric or geometric) and an operator-theoretic shift designed for nonlinear PDEs. These developments enable unique recovery of unknown parameters where previously multiple, active measurements were required.

8. 报告题目 Title：Linear Regularization of Nonlinear Inverse Problems

报告人 Speaker：Sergey Kabanikhin（Novosibirsk State University）

报告摘要 Abstract：Nonlinear inverse problems for hyperbolic differential equations are central to mathematical physics, geophysics, acoustics, and non-destructive testing. While optimization-based iterative solvers require thousands of forward and adjoint simulations, the direct linear regularization framework—originating from the classic Gelfand–Levitan–Marchenko–Krein (GLKM) theory and extended to multi-dimensional settings—reformulates nonlinear coefficient recovery into linear integral equations. This paper provides a comprehensive, rigorous overview of the GLKM framework, its equivalence and connections to the Boundary Control (BC) method, and its discrete formulation. We analyze structured block-Toeplitz matrix implementations, stochastic algorithms (Monte Carlo Neumann-series iterations, randomized Kaczmarz projection), and recent developments integrating Physics-Informed Neural Operators (PI-DeepONet). Finally, we elucidate the fundamental link between unpaired observations and singular value spectrum truncation in ill-posed inverse operators.

9. 报告题目 Title：Volterra models of hereditarian nonlinear dynamical systems

报告人 Speaker：Sidorov Denis （Harbin Institute of Technology）

报告摘要 Abstract：In this talk we investigate an inverse problem for a nonlinear Volterra integral equation of the first kind, characterized by a piecewise continuous kernel whose discontinuity curves are unknown. Such models arise naturally in evolving systems and power networks with energy storage. We develop an iterative solution scheme based on Newton-Kantorovich linearization, providing explicit recurrence formulas for recovering the discontinuity curves. Both a full and a simplified iterative procedure are constructed, and we prove local convergence under standard regularity assumptions. Numerical experiments confirm the method’s fast convergence and robustness, underscoring its practical viability.

10. 报告题目 Title：Semismooth Newton method for sparse QCQP

报告人 Speaker：Ziyan Luo,（Beijing Jiaotong University）

报告摘要 Abstract：Quadratically constrained quadratic programming (QCQP) is notoriously difficult to solve, especially in large-scale and high-dimensional scenarios, where direct computation becomes computationally intractable. The incorporation of sparsity constraints further exacerbates the difficulty, yielding sparse QCQP (SQCQP) problems that severely degrade the performance of conventional solvers. Existing SQCQP solution strategies, including mixed-integer programming reformulations, relaxation schemes, and greedy heuristics, generally suffer from low computational efficiency and unsatisfactory numerical accuracy. This work proposes a novel algorithmic framework for directly solving SQCQP. Specifically, we adopt the P-stationarity concept to establish rigorous first- and second-order optimality conditions for the original problem, which yields a system of nonlinear equations. Under mild assumptions, the generalized Jacobian of the resulting system is proven to be nonsingular. Crucially, based on these theoretical properties, we develop an efficient semismooth Newton-type method that fully exploits inherent sparsity structures, achieves low computational complexity, and guarantees locally quadratic convergence. Extensive numerical experiments further verify that the proposed algorithm outperforms several state-of-the-art solvers in terms of both accuracy and computational efficiency.

11. 报告题目 Title：A Unified Algorithm for Nonconvex Decentralized Nonlinear Optimization

报告人 Speaker：Liping Wang（Nanjing University of Aeronautics and Astronautics）

报告摘要 Abstract：In this paper, we study the decentralized optimization problem of minimizing a finite sum of continuously differentiable and possibly nonconvex functions over a fixed-connected undirected network. We propose a unified decentralized nonconvex algorithmic framework that includes many existing state-of-the-art gradient tracking and quasi-Newton algorithms. A general framework for the convergence analysis of our unified algorithm is presented under both nonconvex and the Kurdyka-Łojasiewicz condition settings. In particular, some new quasi-Newton algorithms under this framework are proposed. Our numerical results show that these newly developed algorithms are very efficient compared with other state-of-the-art algorithms for solving decentralized nonconvex nonlinear optimization.

12. 报告题目 Title：Unwrapping Visual Black-box Models by Interaction Decomposition
报告人 Speaker：Ruxin Wang,（Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences）
报告摘要 Abstract：Concept-based explanation methods have emerged as a prominent framework for interpreting deep neural networks using human-understandable concepts. However, existing approaches are limited to assigning a scalar importance score to a concept, failing to capture the interaction between the concept and its visual context. We argue that overlooking this interaction leaves a predictor's reasoning only partially understood. To address this gap, we introduce IDEA, a novel global post-hoc explanation framework that explicitly models the interaction between a concept and its visual context. IDEA extends interpretability beyond merely identifying influential concepts to diagnosing how a predictor reasons. IDEA requires no task-specific concept annotations and no access to classifier internals.

13. 报告题目 Title：LABO: Latent-free Adaptive Binary Optimizer for Binary Neural Networks
报告人 Speaker：Ovanes Petrosian（Shenzhen MSU-BIT University）
报告摘要 Abstract：Traditionally, the training methods of Binary Neural Networks (BNNs) rely on minimizing the binarization error in forward propagation and approximating the sign function within full-precision (FP) models, and thus do not exploit the natural structure of optimization directly in the space of binary weights. We propose the Latent-free Adaptive Binary Optimizer (LABO), a method that operates entirely without latent FP weights. LABO updates each binary weight through a sign-changing rule that flips its sign according to the gradient evaluated at the binary point, with the proportion of flipped weights governed by an adaptive threshold and the learning rate (LR). It also admits a trainable scaling factor that reintroduces a controlled degree of FP information into the binary optimization space. We also propose BNN Initialization, the weight initialization procedure that preserves gradient and activation variance from layer to layer. Thus, LABO applies to existing convolutional and transformer architectures without structural changes. We provide a convergence analysis that guarantees a finite total number of sign flips. We also characterize the point at which training stops in terms of the loss, showing that changing the signs of any set of binary weights cannot lower the loss beyond a tolerance computed from one gradient evaluation at the trained model. Empirically, across super-resolution, language modeling, and classification, LABO closes, on average, 28.88% of the gap between binary baselines and their FP counterparts, improving over state-of-the-art BNN training methods.

14. 报告题目 Title：Global-Pixel-RRT: An automatic global extraction algorithm for liver vascular system

报告人 Speaker：Jianfeng Zhang（Zhejiang Normal University）

报告摘要 Abstract：Automatic extraction of hepatic vessel centerlines is important for vascular structure analysis, surgical planning, and image-guided intervention, but hepatic vessels in abdominal CT often suffer from low contrast, local discontinuities, indistinct small branches, and interference from background structures. Conventional segmentation–skeletonization pipelines may therefore produce missing branches, false connections, and topological breaks. This paper proposes Global-Pixel-RRT, an image-guided sampling-based path planning algorithm for hepatic vessel skeleton extraction. The method formulates centerline extraction as a global multi-target low-energy path search problem. Pixel- or voxel-level vessel responses guide sampling, parent selection, rewiring, collision detection, and convergence judgment, reducing background expansion caused by purely geometric search. The 2D version operates on liver-ROI-restricted maximum-intensity-projection images, while the 3D version extends node representation, cost computation, feasibility checking, endpoint initialization, path straightening, and node adsorption to CT voxel space. Experiments were conducted on 2D projected images, Vascular Synthesizer volumes, and real CT volumes from an internal dataset, Task08_HepaticVessel, and 3D-IRCADb-01. Comparisons include learning-based segmentation–skeletonization baselines, Otsu thresholding with 3D thinning, and Fast Marching/minimal path. Ablation results show that PixelCost/VoxelCost improves localization, multi-target planning increases branch coverage, and 3D collision detection suppresses erroneous cross-region connections.

15. 报告题目 Title：Fast Numerical Derivatives Based on Multi-interval Fourier Extension

报告人 Speaker：Zhengyu Zhao（Shandong University of Technology）

报告摘要 Abstract：We present a fast and adaptive numerical differentiation method for recovering derivatives from noisy uniformly sampled data on a bounded interval. The method combines multi-interval Fourier extension, truncated singular value regularization, and residual-driven adaptive partitioning within a unified framework. By reconstructing the data on adaptively selected subintervals, it reduces the effective local frequency of oscillatory functions and improves the practical resolution of challenging nonperiodic data. A unified local sampling pattern allows the Fourier extension matrices, derivative operators, and singular value decomposition to be precomputed once and reused throughout the adaptive procedure, yielding a substantially more efficient implementation than previous global Fourier-extension-based methods. An overlap-enhanced local reconstruction variant is also discussed to mitigate endpoint and interface artifacts caused by independent subinterval reconstructions. Theoretical analysis establishes order-optimal convergence, and numerical experiments demonstrate clear improvements in accuracy, efficiency, and robustness. The proposed framework remains effective for first-, second-, and third-order derivative reconstruction, providing an accurate and computationally efficient approach to ill-posed numerical differentiation.

16. 报告题目 Title：Computation and Root Certification of Rayleigh-Wave Dispersion Spectra Based on Multilayer Depth Impedance and the Evans Function

报告人 Speaker：Jianxun Yang（Shenzhen MSU-BIT University）

报告摘要 Abstract：This work presents a stable computational framework for complete Rayleigh-wave dispersion spectra in layered elastic media by combining a multilayer depth-impedance formulation with the Evans function. The depth-impedance approach improves numerical stability in strongly layered models, while the Evans function is used to identify and certify physical dispersion roots. Numerical examples show that the method can reliably recover fundamental and higher-mode branches, including closely spaced roots, and provides a robust forward solver for subsequent studies of multimode behavior and surface-wave inversion.