南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

理学院数学系
Department of Mathematics
College of Science

第十二届全国反问题，成像及其应用会议

The 12th Conference on Inverse Problems, Imaging and Applications

会议手册

中国·深圳

2023 年 05 月 26 日—2023 年 05 月 29 日

南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

南方科技大学
地址：广东省深圳市南山区学苑大道 1088 号

目录

会议信息

反问题及成像的研究目前已是国际和国内数学研究领域比较前沿和热点的课题。为了促进国内外反问题研究领域的学术交流与合作，提高国内研究生和青年教师的科研能力，了解国内外关于反问题各分支领域的最新研究动态，在南方科技大学和北师港浸大联合国际学院汤涛院士、浙江大学包刚教授、复旦大学程晋教授、中国科学院张波研究员、东南大学刘继军教授等积极倡导下，拟定于 2023 年 5 月 26 日至 5 月 29 日（5 月 26 日全天报到）在广东省深圳市南方科技大学举办第十二届全国反问题、成像及其应用年会。会议议题包括电磁散射反问题、地质探测反问题、图像反问题、一般不适定问题、偏微分方程反问题等一系列当前研究的热点问题。

此次会议将邀请国内外反问题与成像等领域的专家学者与会交流，旨在推动国内外反问题与成像等领域的学者之间的交流。

主办单位： 南方科技大学

CSIAM 反问题与成像专委会

协办单位： 哈尔滨工业大学（深圳）

香港中文大学（深圳）

深圳大学

深圳北理莫斯科大学

中国科学院深圳先进技术研究院

深圳国际数学中心（杰曼诺夫数学中心）

深圳国家应用数学中心

广东省计算科学与新材料设计重点实验室

基金支持： 中华人民共和国科技部

国家自然科学基金委

广东省科技厅

深圳市科创委

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张德悦	吉林大学
张磊	浙江工业大学
张晔	深圳北理莫斯科大学

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会议指南

一、会议报到

报到时间：5 月 26 日 09：00--21：00

报到地点：深圳市南方科技大学理学院 1001 报告厅

二、交通指引

1）乘坐飞机到达

深圳宝安国际机场至南方科技大学 1 号门（正门）

a. 乘坐的士约 1 小时，费用约 100 元。

- 出租车乘车点位于 GTC 二楼外东侧平台，可通过 GTC 东侧 13 号门到达出租车上客区。
- 网约车乘车点位于 GTC 楼外南侧，可经 GTC 二楼南侧 15 号门，乘坐扶手电梯或者垂直电梯后到达网约车专用通道。

b. 乘坐地铁约 1 小时，费用约 7 元。

- 地铁 11 号线入口位于 GTC 大厅内，可通过四部垂直梯和两部手扶梯到达 11 号地铁线展厅内。
- 乘坐 11 号线（机场站上地铁，岗厦北方向）在前海湾站转 5 号线（黄贝岭方向），在 5 号线塘朗站下车后在 C 口出站，之后向北步行 525 米即可到达。

c. 深圳宝安国际机场 24 小时服务电话：0755-23456789

d. 深圳机场平面图

2）乘坐高铁（动车）到达

深圳北站至南方科技大学 1 号门（正门）

a. 乘坐的士约 15 分钟，费用约 20 元。

b. 乘坐地铁约 30 分钟，费用约 3 元。

乘坐 5 号线（深圳北站上地铁，赤湾方向）2 站后在塘朗站下车，C 口出站，之后向北步行 525 米即可到达。

3）1 号门（正门）至理学院

理学院位于 1 号门的 1 点钟方向，抬头可见理学院的楼标。

从 1 号门进入校园，直行 100 米（过桥），即可到达。步行路线可参考右图：

三、WIFI 信息

学校免费 WIFI：SUSTech-wifi 或者 SUSTech-wifi-5G

连接 WIFI 后，选择访客登录，请输入手机号获取验证码使用。

四、各日会议地点和就餐地点

- 5 月 26 日全天、5 月 27 日全天报到地点：理学院 1001 报告厅。
- 5 月 27 日上午、5 月 28 日上午大会报告地点：第一科研楼 102 报告厅。
- 5 月 27 日下午分组报告地点：

M1	第一教学楼 107 教室	M5A	第一教学楼 301 教室
M2	第一教学楼 110 教室	M6	第一教学楼 303 教室
M3	第一教学楼 111 教室	M7	第一教学楼 304 教室
M4	第一教学楼 204 教室	M11A	第一教学楼 306 教室

- 5 月 28 日下午分组报告地点

M8	第一教学楼 107 教室	M5B	第一教学楼 301 教室
M9	第一教学楼 110 教室	M13	第一教学楼 304 教室
M10	第一教学楼 111 教室	M11B	第一教学楼 306 教室
M12	第一教学楼 204 教室		

- 5 月 26 日晚餐、5 月 27 日中餐、5 月 28 日中餐、5 月 28 日晚餐地点：学生食堂的中心餐厅。餐厅开放时间：中餐 11:00-13:00，晚餐 17:00-19:00。已完成注册的参会人员凭餐券就餐。
- 5 月 27 日晚宴：凤凰楼(云城店)。时间：18:00-20:30。

  地址：深圳市南山区深圳市南山区西丽街道留仙洞总部基地打石二路南侧云

城万科里集中商业 L4 层 6-10 号。

电话：0755-26921167 0755-26922017 13688846601

会议组委会已安排大巴车接送往返就餐地点。27 日下午分组报告结束后，于 17:40-18:00 在主会场（第一科研楼）旁的学校 7 号门处乘车前往就餐地点。餐后大巴送参会人员回学校或入住的酒店。已完成注册的参会人员凭晚宴券就餐。

- 会场和校内就餐地点请参考下图。校园内有免费校车，参会人员可在 1 号门站上车、科研楼站下车，即可到达第一科研楼和第一教学楼。

五、会议网站

会议网站主页：http://www.smartchair.org/hp/SZMATH/TOP/

六、入校申请

按照学校规定，现在进入校园需要提前在**微信小程序**上申请入校。

以下为入校申请的流程：

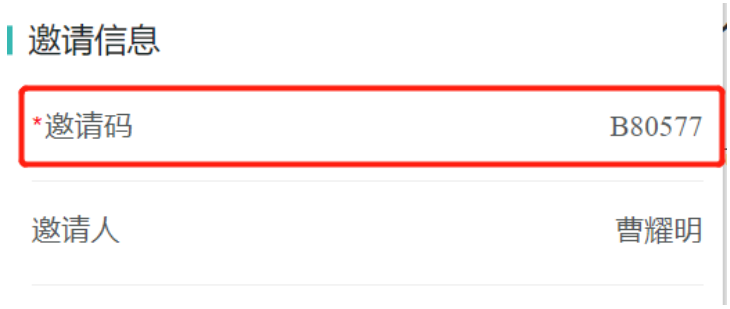
1. 微信打开搜索框，输入 **南科大校外人员进校申请** ，即可在搜索结果里看到 **南科大校外人员进校申请 小程序**，如下图：

2. 点击进入小程序，如下图所示，点选 **入校申请**。

3. 填写个人信息，其中**带红星的为必填项**。

   标题和**来访事由**都写 **参加反问题会议** 即可。

4. 最后一条**邀请信息**的**邀请码**请填 **B80577** 。如下图所示：



5. 审核通过后会生成一个**通行码**。进入校园时，请出示通行码给校门口的门卫工作人员即可。

会议日程总览

5 月 26 日全天	5 月 27 日上午 5 月 28 日上午	5 月 27 日下午 5 月 28 日下午	5 月 29 日全天
会议报到	开幕式 大会报告	分组报告	离会

5 月 26 日　理学院 1001 报告厅	
08:00-21:00	会议报到
17:00-19:00	晚餐

5 月 27 日上午		5 月 28 日上午	
第一科研楼 102 报告厅		第一科研楼 102 报告厅	
8:45-9:00	开幕式	9:00-9:45	杨家青
9:00-9:45	李培军	9:45-10:30	李景治
9:45-10:15	拍照、茶歇	10:30-10:50	茶歇
10:15-11:00	徐翔	10:50-11:20	王旭
11:00-11:45	闫亮	11:20-11:50	翟剑
12:00-13:00	午餐	12:00-13:00	午餐

5 月 27 日下午　分组报告　第一教学楼								
教室	107	110	111	204	301	303	304	306
报告分组	M1	M2	M3	M4	M5A	M6	M7	M11A
13:10-13:35		窦芳芳				陈冲	董国志	文有为
13:35-14:00	陈曦	蒋代军				李建樑	陈德汗	陈云
14:00-14:25	王海兵	李志远	张小群	李文彬	张波	李隆	付振武	崔卓须
14:25-14:50	翟剑	刘晓曼	李程	李晓菲	曾芳	刘可伋	郜广宇	丁乔乔
14:50-15:15	钟敏	阮周生	包承龙	赖俊	张植栋	曲风龙	徐晨	高益铭
15:15-15:40	丁亮	孙春龙	李正一	杨伟	高忆先	宋义壮	谷瑞雪	Florian Bossmann
15:40-16:00	茶歇							
16:00-16:25	闫亮	孙亮亮	周婷	鲁汪涛	马世琪	徐小绪	孙鸿鹏	雷敏
16:25-16:50	龚荣芳	张惠	陈冲	殷涛	董和平	刘晓莉	王薇	李嘉
16:50-17:15	邱越	张磊	金鹏飞	袁晓凯	刁怀安	魏昌坤	夏宇欣	刘志方
17:15-17:40	陈瑜	张植栋	郑斯勤	张海	贾骏雄	吴承宇	李龙	罗守胜
18:00-20:30	晚宴							

5 月 28 日下午　分组报告　第一教学楼							
教室	107	110	111	204	301	304	306
报告分组	M8	M9	M10	M12	M5B	M13	M11B
13:10-13:35							林义尊
13:35-14:00	冯晓莉		刘皓	刘娟			聂梓伟
14:00-14:25	焦雨领	甘文勇	周知	马云云	汪贤超	李佳磊	王超
14:25-14:50	李建樑	江颖	柴利慧	孙凤麟	赵璐	李圆媛	王冬
14:50-15:15	林怡雯	安聪沛	李扬	司苏亮	朱圣鑫	刘庆	王发强
15:15-15:40	欧娜	罗玖	燕雄斌	马冠球	李宏杰	史庆祥	姚文娟
15:40-16:00	茶歇						
16:00-16:25	王洪桥	于洋	何雨晨	向建立	孟庆乐	王丽艳	张建峰
16:25-16:50	王旭	程建伟	潘欢	刘春		于沈文	张建平
16:50-17:15	许伯熹	黄明鸣	Davide Bianchi	郭红霞		邹柏毅	张立
17:15-17:40	张磊	王晨	龙海娥	赵孟洁		邹森	张婕
17:30-19:00	晚餐						

会议报告安排

5月27日上午　第一科研楼102报告厅			
主持人	时间	报告人	题目
包刚	9:00-09:45	李培军	Stability for inverse random source problems
9:45-10:15　茶歇			
程晋	10:15-11:00	徐翔	Inverse Problems on Piezoelectric Equations
	11:00-11:45	闫亮	Deep learning approach for Bayesian inverse problems

5月28日上午　第一科研楼102报告厅			
主持人	时间	报告人	题目
张波	9:00-9:45	杨家青	Direct and inverse wave scattering by multi-layered media
	9:45-10:30	李景治	Shape Derivatives in Scattering: A Riemannian Geometry Approach
9:45-10:15　茶歇			
马富明	10:50-11:20	王旭	Inverse Random Scattering Problems for Stochastic Wave Equations
	11:20-11:50	翟剑	An inverse boundary value problem for a nonlinear elastic wave equation

5 月 27 日下午　第一教学楼 107 教室			
M1：反问题研究的新进展			
主持人	时间	报告人	题目
陆帅	13:35-14:00	陈曦	探测耦合的 Yang-Mills-Higgs 场
	14:00-14:25	王海兵	On domain sampling methods for inverse boundary value problems by one measurement
	14:25-14:50	翟剑	Geometrical inverse problems arising from elastic-wave travel-time tomography
	14:50-15:15	钟敏	Acousto-electric tomography imaging model and algorithm based on two-point gradient Θ method
	15:15-15:40	丁亮	Morozov's discrepancy principle for two non-convex Tikhonov regularizations
15:40-16:00　茶歇			
陆帅	16:00-16:25	闫亮	A hybrid deep learning framework for the limited aperture inverse scattering problem
	16:25-16:50	龚荣芳	A CCBM-based generalized GKB iterative regularization algorithm for inverse Cauchy problems
	16:50-17:15	邱越	Physics-informed invertible neural network for the Koopman operator learning
	17:15-17:40	陈瑜	A numerical method for elliptic equations based on Runge approximation

5 月 27 日下午　第一教学楼 110 教室			
M2：扩散方程反问题及其应用			
主持人	时间	报告人	题目
王泽文	13:10-13:35	窦芳芳	Statement observation problem for stochastic partial differential equations
	13:35-14:00	蒋代军	Convergence Rates of Tikhonov Regularizations for Elliptic and Parabolic Inverse Radiativity Problems
	14:00-14:25	李志远	Inverse source problem for fractional diffusion equation and unique continuation for weak solutions
	14:25-14:50	刘晓曼	Image restoration from double regularizations model with theoretical analysis
	14:50-15:15	阮周生	A modified quasi-boundary value regularization method for time fractional diffusion equation inverse spatial-dependent source problem
	15:15-15:40	孙春龙	Uniqueness and numerical inversions for time-domain fluorescence diffuse optical tomography
15:40-16:00　茶歇			
王海兵	16:00-16:25	孙亮亮	Several kinds of inverse coefficient problems in time-fractional diffusion equations
	16:25-16:50	张惠	Solving an inverse source problem by deep neural network method with convergence and error analysis
	16:50-17:15	张磊	Some progress about shell structure scattering problems on rough surfaces
	17:15-17:40	张植栋	稀疏边界观测下抛物方程中的反源问题

5 月 27 日下午　第一教学楼 111 教室			
M3：成像反问题的理论与算法			
主持人	时间	报告人	题目
邱凌云	14:00-14:25	张小群	AE-FLOW: Autoencoders with Normalizing Flows for Medical Images Anomaly Detection
	14:25-14:50	李程	深度学习医学图像分割
	14:50-15:15	包承龙	Learning Robust Imaging Models without Paired Data
	15:15-15:40	李正一	Solving Boltzmann equation with neural sparse representation
15:40-16:00　茶歇			
邱凌云	16:00-16:25	周婷	An Inverse Problem for Nonlinear Time-dependent Schrodinger Equations with Partial Data
	16:25-16:50	陈冲	Nonconvex Optimization Algorithms in Image Reconstruction for Nonlinear Imaging
	16:50-17:15	金鹏飞	DDRF-CNN: Data-Driven Reference Frame Convolutional Neural Networks
	17:15-17:40	郑斯勤	Lipschitz Stability of Recovering the Conductivity from Internal Current Densities

5 月 27 日下午　第一教学楼 204 教室			
M4：散射与反散射的计算与应用			
主持人	时间	报告人	题目
鲁汪涛	14:00-14:25	李文彬	A stochastic gradient descent approach with partitioned-truncated singular value decomposition for large-scale inverse problems of magnetic modulus data
	14:25-14:50	李晓菲	Neutral inclusions and weakly neutral inclusions
	14:50-15:15	赖俊	Selective focusing of multiple elastic cavities
	15:15-15:40	杨伟	Design and finite element simulation of information open electromagnetic cloak device
15:40-16:00　茶歇			
赖俊	16:00-16:25	鲁汪涛	Scattering of waves in orthotropic elastic media
	16:25-16:50	殷涛	A hybrid boundary integral equation solver for wave equation problem in an interior domain
	16:50-17:15	袁晓凯	An adaptive finite element DtN method for the elastic wave scattering problem in three dimensions
	17:15-17:40	张海	Mathematical theory for topological photonic materials in one dimension

5 月 27 日下午　第一教学楼 301 教室			
M5A：反散射问题和成像			
主持人	时间	报告人	题目
王玉亮	14:00-14:25	张波	Convergence analysis of the Yee scheme on non-uniform grids for 3D Maxwell's equations with the uniaxial PML
	14:25-14:50	曾芳	An interior inverse scattering problem in elasticity
	14:50-15:15	张植栋	单调算子方法求解反位势问题
	15:15-15:40	高忆先	Resonant modal approximation of time-domain elastic scattering from nano-bubbles in elastic materials
15:40-16:00　茶歇			
郭玉坤	16:00-16:25	马世琪	Fixed angle inverse scattering for sound speeds close to constant
	16:25-16:50	董和平	Uniqueness and reconstruction method for inverse elastic wave scattering with phaseless data
	16:50-17:15	刁怀安	Visibility, invisibility and unique recovery of inverse electromagnetic problems with conical singularities
	17:15-17:40	贾骏雄	Variational Inverting Network for Statistical Inverse Problems of Partial Differential Equations

5 月 27 日下午　第一教学楼 303 教室			
M6：数学物理方程及其反问题的理论与算法			
主持人	时间	报告人	题目
杨家青	13:10-13:35	陈冲	Spatiotemoral Imaging with Diffeomorphic Optimal Transportation
	13:35-14:00	李建樑	Inverse source problems for the stochastic wave equations: far-field patterns
	14:00-14:25	李隆	Direct imaging method for reconstructing penetrable locally rough surfaces from phaseless total-field data
	14:25-14:50	刘可伋	Direct reconstruction methods in the ocean waveguide
	14:50-15:15	曲风龙	Simultaneously imaging a conductive medium and various obstacles
	15:15-15:40	宋义壮	Inverse problems of magnetic resonance electrical impedance tomography based on a single measurement
15:40-16:00　茶歇			
曲风龙	16:00-16:25	徐小绪	Uniqueness to inverse grating diffraction problem with infinitely many plane waves at a fixed frequency
	16:25-16:50	刘晓莉	An Accelerated Level-Set Method for Inverse Scattering Problems
	16:50-17:15	魏昌坤	An introduction to the time-domain PML method for wave scattering problems
	17:15-17:40	吴承宇	Direct and inverse scattering by unbounded penetrable rough surfaces

5 月 27 日下午　第一教学楼 304 教室			
M7：正则化算法及应用			
主持人	时间	报告人	题目
张晔	13:10-13:35	董国志	Second-order flows as computational models for inverse problems and beyond
	13:35-14:00	陈德汗	Statistical linear inverse problems in Banach spaces
	14:00-14:25	付振武	Convergence analysis of a generalized Levenberg-Marquardt method for possibly non-smooth inverse problems
	14:25-14:50	郜广宇	A Fast Data-Driven Iteratively Regularized Method with Convex Penalty for Solving Ill-Posed Problems
	14:50-15:15	徐晨	Estimating the memory parameter for possibly non-linear and non-Gaussian time series with wavelets
	15:15-15:40	谷瑞雪	Heuristic rule for inexact Newton-Landweber iteration with convex penalty terms of nonlinear ill-posed problems
15:40-16:00　茶歇			
张晔	16:00-16:25	孙鸿鹏	An Investigation on Semismooth Newton based Augmented Lagrangian Method for Image Restoration
	16:25-16:50	王薇	Dual gradient method for ill-posed problems using multiple repeated measurement data
	16:50-17:15	夏宇欣	Convergence analysis of inexact Newton-Landweber iteration under H\"{o}lder stability
	17:15-17:40	李龙	Fluid Velocity Reconstruction by a Deep Neural Network Approximating Variational Data Assimilation

5 月 27 日下午　第一教学楼 306 教室			
M11A：数学图像处理和反问题			
主持人	时间	报告人	题目
董彬	13:10-13:35	文有为	Image segmentation using Bayesian inference for convex variant Mumford-Shah variational model
	13:35-14:00	陈云	A content-adaptive unstructured grid based regularized CT reconstruction method with a SART-type preconditioned fixed-point proximity algorithm
	14:00-14:25	崔卓须	快速磁共振成像：深度迭代正则化方法论
文有为	14:25-14:50	丁乔乔	A Shortened Model for Logan Reference Plot Implemented via the Self-Supervised Neural Network for Parametric PET Imaging
	14:50-15:15	高益铭	Template-based CT reconstruction with optimal transport and total generalized variation
	15:15-15:40	Florian Bossmann	ORKA: A new model for tracking moving and deforming objects
15:40-16:00　茶歇			
吴春林	16:00-16:25	雷敏	Implicit Surface Reconstruction through Meshless Methods
	16:25-16:50	李嘉	Sparse approximation and data processing
常慧宾	16:50-17:15	刘志方	Variational Rician Noise Removal via Splitting on Spheres
	17:15-17:40	罗守胜	Superiorized iteration algorithm for XCT image reconstruction and segmentation simultaneously

5 月 28 日下午　第一教学楼 107 教室			
M8：随机反问题与不确定性量化			
主持人	时间	报告人	题目
闫亮	13:35-14:00	冯晓莉	Theoretical analysis and numerical reconstruction for three kinds of inverse random problems
	14:00-14:25	焦雨领	Current density impedance imaging with PINNs
	14:25-14:50	李建樑	Inverse random potential scattering for elastic waves
	14:50-15:15	林怡雯	Scattering and Inverse Scattering by a Random Periodic Structure
	15:15-15:40	欧娜	A low-rank approximated multiscale method for PDEs with random coefficients
15:40-16:00　茶歇			
徐翔	16:00-16:25	王洪桥	Multi-fidelity deep learning method for the inversion of force function in PDEs
	16:25-16:50	王旭	Stochastic inverse source problems for fractional diffusion equations
	16:50-17:15	许伯熹	Linearized Inverse Potential Problems at a High Frequency
	17:15-17:40	张磊	Mathematical analysis for composite scattering in multilayered mediums

5 月 28 日下午　第一教学楼 110 教室			
M9：复杂过程辨识方法研究及工程应用			
主持人	时间	报告人	题目
衡益	14:00-14:25	甘文勇	A WENO finite volume method based on radial basis function for hyperbolic conservation laws
	14:25-14:50	江颖	A fast algorithm for solving boundary integral equations on domain with corners
	14:50-15:15	安聪沛	The springback penalty for robust signal recovery
	15:15-15:40	罗玖	基于机理与数据融合的复杂 PDE 系统逆向设计与应用
15:40-16:00　茶歇			
江颖	16:00-16:25	于洋	一个求解粘弹性动力多宗量辨识反问题的数值方法
	16:25-16:50	程建伟	电力设备多物理场反问题求解技术与工程应用
	16:50-17:15	黄明鸣	基于端到端卷积的生成对抗网络求解器在生物传热反问题中的应用
	17:15-17:40	王晨	贝叶斯蒙特卡罗方法在三维瞬态热传导反问题求解中的应用

5 月 28 日下午　第一教学楼 111 教室			
M10：微分方程反问题与数据驱动方法			
主持人	时间	报告人	题目
李文彬	13:35-14:00	刘皓	Theories for Learning Functions and Operators with Low-Dimensional Structures by Deep Neural Networks
	14:00-14:25	周知	Hybrid Neural-Network FEM Approximation of Diffusion Coefficient in Elliptic and Parabolic Problems
	14:25-14:50	柴利慧	基于随机梯度重构的地震波成像方法
	14:50-15:15	李扬	3D frequency-domain elastic wave modeling with spectral element methods using direct solvers
	15:15-15:40	燕雄斌	利用深度学习求解欠扩散问题中的正反问题
15:40-16:00　茶歇			
梁慧	16:00-16:25	何雨晨	Identifiability of PDEs from Trajectory Data and Some Novel Methods based on Group Projected Subspace Pursuit
	16:25-16:50	潘欢	Orientation estimation of cryo-EM images using projected gradient descent method
	16:50-17:15	Davide Bianchi	Uniformly convex neural networks and non-stationary iterated network Tikhonov (iNETT) method
	17:15-17:40	龙海娥	Stochastic Asymptotical Regularization Stochastic asymptotical regularization for nonlinear ill-posed problems

5 月 28 日下午　第一教学楼 204 教室			
M12：反散射问题的分析与计算			
主持人	时间	报告人	题目
孙瑶	13:35-14:00	刘娟	Determination of some new eigenvalues from scattered field
	14:00-14:25	马云云	Fourier-Galerkin method for the transmission eigenvalue problem based on a boundary integral formulation
	14:25-14:50	孙凤麟	Reconstruction of acoustic sources from multi-frequency phaseless far-field data
	14:50-15:15	司苏亮	Increasing stability for the inverse source problems in elastodynamics
	15:15-15:40	马冠球	Imaging a moving point source from multi-frequency data measured at one and sparse observation directions (part I): far-field case
15:40-16:00　茶歇			
刘娟	16:00-16:25	向建立	Uniqueness in determining rectangular grating profiles with a single incoming wave: TM polarization case
	16:25-16:50	刘春	Increasing stability for inverse acoustic source problems in the time domain
	16:50-17:15	郭红霞	Inverse wave-number-dependent source problems for the Helmholtz equation with multi-frequency factorization method
	17:15-17:40	赵孟洁	Direct sampling method to inverse wave-number-dependent source problems (part I): determination of the support of a stationary source

5 月 28 日下午　第一教学楼 301 教室			
M5B：反散射问题和成像			
主持人	时间	报告人	题目
王玉亮	14:00-14:25	汪贤超	Geometrical properties of transmission eigenfunctions
	14:25-14:50	赵璐	Inverse obstacle scattering for elastic waves in the time domain
	14:50-15:15	朱圣鑫	Fast inference for restricted maximum likelihood methods with linear mixed models
	15:15-15:40	李宏杰	Minnaert resonances for bubbles in soft elastic materials
15:40-16:00　茶歇			
王玉亮	16:00-16:25	孟庆乐	Effective Medium Theory for Embedded Obstacles in Elasticity with Applications to Inverse Problems
	16:25-16:50		
	16:50-17:15		
	17:15-17:40		

5 月 28 日下午　第一教学楼 306 教室			
M11B：数学图像处理和反问题			
主持人	时间	报告人	题目
张小群	13:10-13:35	林义尊	Convergence Rate Analysis for Fixed-Point Iterations of Generalized Averaged Nonexpansive Operators
	13:35-14:00	聂梓伟	基于最优传输的非刚性图像配准模型、理论和算法
	14:00-14:25	王超	A novel tensor regularization of nuclear over Frobenius norms for low rank tensor recovery
陈冲	14:25-14:50	王冬	医学成像：模型驱动 VS 数据驱动
	14:50-15:15	王发强	Learnable Mixture Distribution Prior for Image Denoising
	15:15-15:40	姚文娟	Multiplicative noise removal and contrast enhancement for SAR images based on a total fractional-order variation model
15:40-16:00　茶歇			
曾超	16:00-16:25	张建峰	Variational image-based Rapidly-exploring Random Tree and its applications
	16:25-16:50	张建平	Variational Image Registration Model with Diffeomorphism Constraints and Its Implementation
刘志方	16:50-17:15	张立	面向区域的小样本图像分割
	17:15-17:40	张婕	Optimal Transport for Positive and Unlabeled Learning And Its Application in Windshear Detection

5月28日下午　第一教学楼304教室			
M13：自由报告			
主持人	时间	报告人	题目
郭玉坤	14:00-14:25	李佳磊	Reconstruction of Multiscale Electromagnetic Sources from Multi-frequency Electric Far Field Patterns at Sparse Observation Directions
	14:25-14:50	李圆媛	Two-layer networks with the ReLUˆk activation function: Barron spaces and derivative approximation
	14:50-15:15	刘庆	A mixed element scheme for the Helmholtz transmission eigenvalue problem for anisotropic media
	15:15-15:40	史庆祥	Identification of acoustic point sources in a two-layered medium from multi-frequency sparse far field patterns
15:40-16:00　茶歇			
刘晓东	16:00-16:25	王丽艳	心电图成像的等效模型与时空联合的反演算法
	16:25-16:50	于沈文	Traceability of Water Pollution: Dynamic CGO Solutions for Inverse Source Problem and Its Application
	16:50-17:15	邹柏毅	WANCO: Weak Adversarial Network for Constrained Optimization problems
	17:15-17:40	邹森	A linearization approach to inverse Schr\"odinger potential problem with power type nonlinearities

报告题目和摘要

大会报告

Stability for inverse random source problems

李培军

普渡大学

Abstract: In the field of inverse problems, the estimation of an unknown source term from indirect observations is a fundamental challenge. Random sources add another level of complexity to this problem due to their uncertainties. In this talk, we will focus on the stability estimates for inverse random source problems, specifically for the stochastic Helmholtz equation driven by a white noise. An overview will be provided on the existing results for estimating the stability of the solution in deterministic settings, and our recent findings will be presented for the stochastic case. We will also discuss the challenges involved in inverse random source problems and highlight potential avenues for future research.

Inverse Problems on Piezoelectric Equations

徐翔

浙江大学

Abstract: In this talk, recent progress on inverse problems for piezoelectric equations is discussed. We show a uniqueness result on recovering coefficients of piecewise homogeneous piezoelectric equations from a localized Dirichlet-to-Neumann map on partial boundaries. Assume the bounded domain can be divided into finite subdomains, in which the unknown coefficients including elastic tensor, piezoelectric tensor and dielectric tensor are constants. Two different cases are considered: the subdomains are either known and Lipschitz, or unknown and subanalytic. For both cases, the unknown coefficients can be uniquely determined from a given localized Dirichlet-to-Neumann map. Moreover, for a specific hexagonal piezoelectric equation, we obtained a first order perturbation formula for the phase velocity of Bleustein-Gulyaev (BG) waves, which expresses the shift in the velocity from its comparative value, caused by the perturbation of the elasticity tensor, the piezoelectric tensor and of the dielectric tensor.

Deep learning approach for Bayesian inverse problems

闫亮

东南大学

Abstract: Obtaining samples from the posterior distribution of Bayesian inverse problems is a long-standing challenging, especially when the forward operator is modeled by partial differential equation (PDE). In this talk, we will discuss how to leverage the deep learning's capabilities to tackle this challenge. Several fast and efficient deep neural network (DNN)-based approaches for accelerating simulations in sample generation will be described. A novel framework based on invertible neural networks using normalizing flow is also demonstrated.

Direct and inverse wave scattering by multi-layered media

杨家青

西安交通大学

Abstract: In this talk, I will report some recent developments about the wave scattering problems associated with multi-layered media. New numerical methods are presented in solving the wave scattering problems for Helmholtz equations. The uniqueness issue is then addressed for inverse problems of determining layered media with possible embedded obstacles by near-field measurements. Finally, several inversion algorithms are proposed with numerical experiments which illustrate the effectiveness of the algorithms.

Shape Derivatives in Scattering: A Riemannian Geometry Approach

李景治

南方科大学

Abstract: This talk presents the "derivative" of solutions of second-order PDE problems, in particular scattering ones, with respect to the shape of the domain. A rigorous approach relies on encoding shape variation by means of deformation scalar, vector or tensor fields, which will supply the directions for taking shape derivatives. These derivatives and methods to compute them numerically are key tools for studying shape sensitivity, performing gradient based shape optimization, and small-variation shape uncertainty quantification. A unifying view of second-order PDE problems recasts them in the language of differential geometry. Fittingly, the shape deformation through solution fields matches the concept of Lie derivative. This paves the way for a unified treatment of shape differentiation in the framework of differential geometry. Applications in acoustic, electromagnetic and elastic scattering problems reveal the extraordinary power of the machinery.

Inverse Random Scattering Problems for Stochastic Wave Equations

王旭

中科院科学院数学与系统科学研究院

Abstract: In this talk, inverse random scattering problems with a random source or potential will be introduced for different stochastic time-harmonic wave equations. The unknown random source or potential is assumed to be a generalized isotropic Gaussian random field with its covariance operator being a classical pseudo-differential operator. With information of the data observed in a bounded domain, the strength of the random source or potential, involved in the principal symbol of its covariance operator, is shown to be uniquely determined by a single realization of the magnitude of the wave field averaged over the frequency band with probability one.

An inverse boundary value problem for a nonlinear elastic wave equation

翟剑

复旦大学

Abstract: We consider an inverse boundary value problem for a nonlinear model of elastic waves. We show that all the material parameters appearing in the equation can be uniquely determined from boundary measurements under certain geometric conditions. The proof is based on the higher order linearization and the construction of Gaussian beam solutions.

M1：反问题研究的新进展

（报告摘要按照姓氏拼音排序）

探测耦合的 Yang-Mills-Higgs 场

陈曦

上海数学中心

Abstract: Yang-Mills-Higgs 场描述了粒子物理标准模型中玻色子携带的电磁、弱、强三大基本力的非交换场。报告的内容是通过局部激发的粒子场对真空态进行扰动探测 Yang-Mills-Higgs 场。

A numerical method for elliptic equations based on Runge approximation

陈瑜

上海财经大学

Abstract: Runge approximation refers to the approximation of a solution to a partial differential equation in a domain by solutions of the same equation in a larger domain containing it. In this talk, we will give a numerical method for elliptic equations based on Runge approximation. Some results on quantitative Runge approximation and the error estimate based on it will be presented, illustrated by some numerical examples. The method shows flexibility in practice and can be potentially applied to inverse problems and design problems. This is a joint work with Prof. Jin Cheng.

Morozov's discrepancy principle for two non-convex Tikhonov regularizations

丁亮

东北林业大学

Abstract: Morozov's discrepancy principle (MDP) is commonly adopted in Tikhonov regularization for choosing the regularization parameter. However, for the non-convex regularization, there may exist multiple minimizers and one can not ensure the existence of α such that MDP i.e. $\tau_1\delta\leq \|F(x_{\alpha}^{\delta})-y^{\delta}\|_Y\leq \tau_2 \delta$ $(1\le \tau_1<\tau_2)$ holds. In this report, we discuss the applications of MDP for two non-convex regularizaitons. 1. For the non-linear inverse problems with the general convex penalty, we prove the existence of the regularization parameter α under MDP if $\tau_2\ge (3+2\gamma)\tau_1$, where $\gamma>0$ is a parameter in a tangential cone condition. 2. MDP is considered for linear (or nonlinear ill-posed problems) with the non-convex $\alpha\ell_1-\beta\ell_2$ sparsity regularizer ($\alpha>\beta>0$). It is shown that if τ_1 and τ_2 satisfies some conditions, there exists a regularization parameter α such that MDP holds. Furthermore, for the above two cases, it is shown that α converges to 0 as $\delta\rightarrow 0$. In addition, well-posedness and convergence rate results are presented for the regularized solution under MDP. Numerical simulation results are reported to illustrate the efficiency of the proposed approach.

References:

1. Ding L and Han W. $\alpha\ell_{1}-\beta\ell_{2}$ regularization for sparse recovery, Inverse Problems, 2019, 35: 125009.

2. Ding L and Han W. A projected gradient method for $\alpha\ell_{1}-\beta\ell_{2}$ sparsity regularization, Inverse Problems, 2020, 36: 125012.

3. Ding L and Han W. Morozov's discrepancy principle for Tikhonov regularization of non-linear inverse problems with general convex penalty, Inverse Problems and Imaging. 2023, 17: 157-179.

4. Ding L and Han W. $\alpha\ell_{1}-\beta\ell_{2}$ sparsity regularization for nonlinear ill-posed problems, arXiv: 2007.11377v1."

A CCBM-based generalized GKB iterative regularization algorithm for inverse Cauchy problems

龚荣芳

南京航空航天大学

Abstract: This talk examines inverse Cauchy problems that are governed by a kind of elliptic partial differential equation. The inverse problems involve recovering the missing data on an inaccessible boundary from the measured data on an accessible boundary, which is severely ill-posed. By using the coupled complex boundary method (CCBM), which integrates both Dirichlet and Neumann data into a single Robin boundary condition, we reformulate the underlying problem into an operator equation. Based on this new formulation, we study the solution existence issue of the reduced problem with noisy data. A Golub-Kahan bidiagonalization (GKB) process together with Givens rotation is employed for iteratively solving the proposed operator equation. The regularizing property of the developed method, called CCBM-GKB, and its convergence rate results are proved under a posteriori stopping rule. Finally, a linear finite element method is used for the numerical realization of CCBM-GKB. Various numerical experiments demonstrate that CCBM-GKB is a kind of accelerated iterative regularization method, as it is much faster than the classic Landweber method.

Physics-informed invertible neural network for the Koopman operator learning

邱越

重庆大学

Abstract: The Koopman operator is used to embed a nonlinear system into an infinite, yet linear system with a set of observable functions. However, manually selecting observable functions that span the invariant subspace of the Koopman operator based on prior knowledge is inefficient and challenging, particularly when little or no information is available about the underlying system. Furthermore, current methodologies tend to disregard the importance of the invertibility of observable functions, which leads to inaccurate results. To address these challenges, we propose the so-called FlowDMD, a Flow-based Dynamic Mode Decomposition that utilizes the Coupling Flow Invertible Neural Network (CF-INN) framework. FlowDMD leverages the intrinsically invertible characteristics of the CF-INN to learn the invariant subspaces of the Koopman operator and accurately reconstruct state variables. Numerical experiments demonstrate the superior performance of our algorithm compared to state-of-the-art methodologies.

On domain sampling methods for inverse boundary value problems by one measurement

王海兵

东南大学

Abstract: We consider an inverse boundary value problem for the Laplace equation, which discusses the reconstruction of an unknown target inside the background medium from one boundary measurement. We are interested in two domain sampling methods, i.e., the range test and no-response test. We study the convergence and numerical realizations of these methods. Some new techniques are proposed to set up efficient algorithms, which yield reasonably good numerical reconstructions. To demonstrate the performance of proposed algorithms, we show several numerical examples for different shapes of unknown targets with noisy measurement data. Some key ingredients of numerical implementations are discussed in detail.

A hybrid deep learning framework for the limited aperture inverse scattering problem

闫亮

东南大学

Abstract: In this talk, we are concerned with the limited aperture inverse scattering problem with the impedance boundary condition, given far-field data for one incident direction at a fixed frequency. It is noticed that, to solve such an inverse scattering problem, iterative numerical algorithms based on the PDE-constrained optimization are commonly need a reasonable initial guess and a forward solver at each iteration step. To overcome these issues, a hybrid deep learning framework based on the scattering informed neural network(SINN) and a least squares method is proposed to simultaneously reconstruct the shape and the impedance. In this framework, SINN is trained to learn both the shape of the obstacle and the density function of the single layer potential with limited aperture data, and then, the learned shape and density function are applied in the least squares method to recover the impedance. Several numerical examples are presented to show the promising feasibility of our method.

Geometrical inverse problems arising from elastic-wave travel-time tomography

翟剑

复旦大学

Abstract: We consider the determination of anisotropic perturbation of an isotropic elastic body from travel-time measurement. For the perturbation of P waves, we arrived at a standard tensor tomography of a rank-four tensor on a Riemannian manifold. Perturbation of S waves gives a mixed ray transform of a different (but closely related) rank-four tensor. We discuss the uniqueness results for these two types of geometrical inverse problems under certain situations.

Acousto-electric tomography imaging model and algorithm based on two-point gradient Θ method

钟敏

东南大学

Abstract: We study the numerical reconstruction problem in acousto-electric tomography of recovering the conductivity distribution in a bounded domain from interior power density data. We propose a numerical method for recovering discontinuous conductivity distributions, by utilizing the two point gradient method, the piecewise constant conductivity can be efficiently reconstructed. Extensive numerical experiments are presented to illustrate the feasibility of the proposed approach.

M2：扩散方程反问题及其应用

（报告摘要按照姓氏拼音排序）

Statement observation problem for stochastic partial differential equations

窦芳芳

电子科技大学

Abstract: This talk studies statement observation problem of stochastic parabolic equations. Conditional stability and regularization methods for this problem are proved. Numerical method is proposed with verification by examples.

Convergence Rates of Tikhonov Regularizations for Elliptic and Parabolic Inverse Radiativity Problems

蒋代军

华中师范大学

Abstract: In this talk, we shall study the convergence rates of the Tikhonov regularized solutions for the recovery of the radiativities in elliptic and parabolic systems in general dimensional spaces. The conditional stability estimates are first derived. Due to the difficulty of the verification of the existing source conditions or nonlinearity conditions of the inverse radiativity problems in high dimensional spaces, some new variational source conditions are proposed. The conditions are rigorously verified in general dimensional spaces under the conditional stability estimates. We will also derive the reasonable convergence rates under the new source conditions, and the results reveal the explicit relation between the regularity of the radiativities and the convergence rates.

Inverse source problem for fractional diffusion equation and unique continuation for weak solutions

李志远

山东理工大学

Abstract: In this talk, we will show the sharp uniqueness for an inverse x-source problem for a one-dimensional time-fractional diffusion equation with a zeroth-order term by the minimum possible lateral Cauchy data. The key ingredient is the unique continuation which holds for weak solutions.

Image restoration from double regularizations model with theoretical analysis

刘晓曼

南京农业大学

Abstract: Consider the image restoration from incomplete noisy frequency data with total variation and sparsity regularizing penalty terms. Firstly, we establish an unconstrained optimization model with different smooth approximations on the regularizing terms. Then, to weaken the amount of computations for cost functional with total variation term, the alternating iterative scheme is developed to obtain the exact solution through shrinkage thresholding in inner loop, while the nonlinear Euler equation is appropriately linearized at each iteration in exterior loop, yielding a linear system with diagonal coefficient matrix in frequency domain. Finally the linearized iteration is proven to be convergent in generalized sense for suitable regularizing parameters, and the error between the linearized iterative solution and the one gotten from the exact nonlinear Euler equation is rigorously estimated, revealing the essence of the proposed alternative iteration scheme. Numerical tests for different configurations show the validity of the proposed scheme, compared with some existing algorithms.

A modified quasi-boundary value regularization method for time fractional diffusion equation inverse spatial-dependent source problem

阮周生

东华理工大学

Abstract: In this talk, a modified quasi-boundary value regularization method is proposed to solve an inverse source problem for time fractional diffusion equation. First, the regularization problem is proposed and the existence and the uniqueness of the regularized solution are proven. Then based on some source condition for the source term and the selection strategies for the regularization parameter, the a prior convergence rate and the posteriori convergence rate of regularization solution are derived by using the eigenfunction expansion method. Next, an all-in-one matrix form with block-Toeplitz structure is obtained by using the finite difference discretization for the regularized problem, and an efficient preconditioning technique is adopted to approximately solve the regularization solution. Finally, several numerical examples are chosen to evaluate the effectiveness of the inversion method.

Uniqueness and numerical inversions for time-domain fluorescence diffuse optical tomography

孙春龙

南京航空航天大学

Abstract: The time-domain fluorescence diffuse optical tomography (FDOT) is to recover the distribution of fluorophores in biological tissue from the time domain measurement on the boundary. With the Laplace transform and the knowledge of complex analysis, we build the uniqueness theorem of this inverse problem. Further, we identify the location of the distribution of fluorophores over a point, refer as a point target. We theoretically investigate what is the minimal number of measurements to determine the point target location, analyzing the determinant of sensitivity matrix.

Several kinds of inverse coefficient problems in time-fractional diffusion

孙亮亮

西北师范大学

Abstract: In this talk, we consider some coefficient identification problems for the time-fractional diffusion equations. We firstly establish some well-posedness results of the forward problems, and also give some method and frame of studying the forward problem. Then we introduce some technique for researching the inverse problems. Finally we employ some iterative regularization algorithm to construct the unknown coefficients.

Solving an inverse source problem by deep neural network method with convergence and error analysis

张惠

东南大学

Abstract: For the inverse source problem of an elliptic system using noisy internal measurement as inversion input, we approximate its solution by neural network function, which is obtained by optimizing an empirical loss function with appropriate regularizing terms. We analyze the convergence of the general loss from noisy inversion input data in Deep Galerkin Method by the regularizing empirical loss function. Based on the upper bound of the expected loss function by its regularizing empirical form, we establish the upper bound of the expected loss function at the minimizer of the regularizing empirical noisy loss function in terms of the number of sampling points as well as the noise level quantitatively, for suitably chosen regularizing parameters and regularizing terms. Then, by specifying the number of sampling points in terms of noise level of inversion input data, we establish the error orders representing the difference between the neural network solution and the exact one, under some a-priori restrictions on the source. Finally, we give numerical implementations for several examples to verify our theoretical results.

Some progress about shell structure scattering problems on rough surfaces

张磊

浙江工业大学

Abstract: As the shell structure is often used in underwater targets, the acoustic scattering problem of underwater shells is a concerned question in many fields for a long time. It is also the foundation of target reconstruction in the field of underwater acoustics. In this talk, we mainly focus on the scattering and inverse scattering of rough surfaces and shell structures. We introduce a novel integral equation for the scattering problem. The numerical methods for the integral equation are studied based on the analysis of the integral kernel. Then we prove the convergence of the algorithm and show some numerical results for the scattering problems. Finally, we will introduce our ongoing research work.

稀疏边界观测下抛物方程中的反源问题

张植栋

中山大学

Abstract: 本报告考虑的是抛物方程中的反源问题，其中未知源项具有较为一般的半离散格式，所使用的观测数据为解在边界的通量。出于节约成本的考虑，我们希望尽可能地缩小观测区域，这也是稀疏一词的由来。使用拉普拉斯变换、复分析等工具，我们严格证明了此反源问题的唯一性定理，即边界任意非空开集上的通量观测可以唯一确定拥有半离散格式的未知源项。在此之后，我们设计了一些数值算法并尝试了一些算例。在最后，我们给出一些关于此反源问题可能的后续工作。

M3：成像反问题的理论与算法

（报告摘要按照姓氏拼音排序）

Learning Robust Imaging Models without Paired Data

包承龙

清华大学

Abstract: The observations in practical imaging systems always contain complex noise such that classical approaches are difficult to obtain satisfactory results. In recent years, deep neural networks directly learned a map between the noisy and clean images based on the training on paired data. Despite its promising results in various tasks, collecting the training data is difficult and time-consuming in practice. In this talk, in the unpaired data regime, we will discuss our recent progress for building AI-aided robust models and their applications in image processing. Leveraging the Bayesian inference framework, our model combines classical mathematical modeling and deep neural networks to improve interpretability. Experimental results on various real datasets validate the advantages of the proposed methods.

Nonconvex Optimization Algorithms in Image Reconstruction for Nonlinear Imaging

陈冲

中国科学院数学与系统科学研究院

Abstract: Nonlinear imaging has high degree of task-specific utilities for medical, security, and other imaging applications, such as quantitative dual-energy CT, digital breast tomosynthesis, phase retrieval. Accurate image reconstruction in nonlinear imaging remains a challenging task, largely because its forward operator is nonlinear. Because of the nonlinear data model in image reconstruction, the optimization problems devised are generally nonconvex. In the talk, I will discuss an extended primal-dual (EPD) algorithm framework that we have developed for image reconstruction through solving nonconvex optimization problems in a class of nonlinear imaging. Moreover, under proper assumptions, we would also discuss the convergence of the schemes for the general model. Extensive numerical studies are carried out to verify that the EPD algorithm framework can numerically accurately reconstruct images in dual-energy CT.

DDRF-CNN: Data-Driven Reference Frame Convolutional Neural Networks

金鹏飞

北京大学

Abstract: Many scientific and engineering datasets are presented in non-Euclidean structures and naturally lack global parameterizations or coordinate systems. The analysis and processing of such geometric data rely on local reference frames (LRFs). Traditional and recently emerging geometric deep learning methods attempt to find a suitable way to construct LRFs. Some recent work has observed that the best-performing LRFs depend on the data and the tasks. Inspired by this observation, we propose data-driven reference frame convolutional neural networks, called DDRF-CNNs, which are a novel family of geometric neural networks for 3D feature extraction and shape generation. DDRF-CNNs rely on LRFs inferred by neural networks trained on downstream tasks and data, instead of LRFs constructed using fixed formulas. In this way, feature representations or generated shapes are obtained that are more beneficial for downstream tasks. Comprehensive experiments show that the proposed DDRF-CNNs achieve similar or better results than state-of-the-art point cloud classification and reconstruction methods.

深度学习医学图像分割

李程

中国科学院深圳先进技术研究院

Abstract: 医学图像分割对病变、组织及器官的定性及定量分析至关重要。临床主要依赖放射科医生手动划分感兴趣区域，这极度增加了放射科医生的工作量。急需开发快速、精准且鲁棒的自动分割算法。目前，全监督深度学习模型在一些医学图像分割任务上取得了令人满意的结果，但其在临床的广泛应用仍然面临着一系列挑战。报告将针对其中的四个挑战，分别为分割目标异质性大、医学图像数据复杂度高、针对高维数据开发的模型计算需求大效率低以及标注训练样本少，介绍我们在医学图像分割领域的相关工作及取得的成果。

Solving Boltzmann equation with neural sparse representation

李正一

北京大学

Abstract: We consider the neural sparse representation to solve Boltzmann equation with BGK and quadratic collision model, where a network-based ansatz that can approximate the distribution function with extremely high efficiency is proposed. Precisely, fully connected neural networks are employed in the time and spatial space so as to avoid the discretization in space and time. Different low-rank representations are utilized in the microscopic velocity for the BGK and quadratic collision model, resulting in a significant reduction in the degree of freedom. We approximate the discrete velocity distribution in the BGK model using the canonical polyadic decomposition. For the quadratic collision model, a data-driven, SVD-based linear basis is built based on the BGK solution. All these will significantly improve the efficiency of the network when solving Boltzmann equation. Moreover, the specially designed adaptive-weight loss function is proposed with the strategies as multi-scale input and Maxwellian splitting applied to further enhance the approximation efficiency and speed up the learning process. Several numerical experiments, including 1D wave and Sod problems and 2D wave problem, demonstrate the effectiveness of these neural sparse representation methods.

AE-FLOW: Autoencoders with Normalizing Flows for Medical Images Anomaly Detection

张小群

上海交通大学

Abstract: Anomaly detection from medical images is an important task for clinical screening and diagnosis. In general, a large dataset of normal images is available while only few abnormal images can be collected in clinical practice. By mimicking the diagnosis process of radiologists, we attempt to tackle this problem by learning a tractable distribution of normal images and identify anomalies by differentiating the original image and the reconstructed normal image. More specifically, we propose a normalizing flow based autoencoder for an efficient and tractable representation of normal medical images. The anomaly score consists of the likelihood originated from the normalizing flow and the reconstruction error of the autoencoder, which allows to identify the abnormality and provide an interpretability at both image and pixel levels. Experimental evaluation on different medical l images datasets showed that the proposed model outperformed the other approaches by a large margin, which validated the effectiveness and robustness of the proposed method.

Lipschitz Stability of Recovering the Conductivity from Internal Current Densities

郑斯勤

清华大学

Abstract: Hybrid imaging techniques have been developed recently to produce clearer images than those produced by electrical impedance tomography. We focus on the inverse problem arising in the quantitative step of many hybrid imaging methods, formulated as recovering the isotropic conductivity of an object given internal current densities generated by applying different boundary conditions to the electrostatic equation. We provide a local Lipschitz stability for the general inverse problem in both full and partial data cases.

An Inverse Problem for Nonlinear Time-dependent Schrodinger Equations with Partial Data

周婷

浙江大学

Abstract: In this talk, I will present some recent results on solving inverse boundary value problems for nonlinear PDEs, especially for a time-dependent Schrodinger equation with time-dependent potentials with partial boundary Dirichlet-to-Neumann map. After a higher order linearization step, the problem will be reduced to implementing special geometrical optics (GO) solutions to prove the uniqueness and stability of the reconstruction. This is a joint work with my PhD student Xuezhu Lu and Prof. Ru-Yu Lai.

M4：散射与反散射的计算与应用

（报告摘要按照姓氏拼音排序）

Selective focusing of multiple elastic cavities

赖俊

浙江大学

Abstract: This talk is concerned with the inverse time-harmonic elastic scattering of multiple small and well-resolved cavities in two dimensions. We extend the so-called D.O.R.T. method to this case so that selective focusing can be achieved on each cavity with far field measurements. A rigorous mathematical justification for the related eigenfunctions of the time-reversal operator to the location of the cavities is presented based on the asymptotic analysis of the far field operator and decaying property of oscillatory integrals. We show that each cavity gives rise to five significant eigenvalues while each corresponding eigenfunction generates an incident wave focusing selectively on that cavity. Numerical experiments are given to verify the theoretical result.

A stochastic gradient descent approach with partitioned-truncated singular value decomposition for large-scale inverse problems of magnetic modulus data

李文彬

哈尔滨工业大学深圳分校

Abstract: We propose a stochastic gradient descent approach with partitioned-truncated singular value decomposition for large-scale inverse problems of magnetic modulus data. Motivated by a uniqueness theorem in gravity inverse problem and realizing the similarity between gravity and magnetic inverse problems, we propose to solve the level-set function modeling the volume susceptibility distribution from the nonlinear magnetic modulus data. To deal with large-scale data, we employ a mini-batch stochastic gradient descent approach with random reshuffling when solving the optimization problem of the inverse problem. We propose a stepsize rule for the stochastic gradient descent according to the Courant-Friedrichs-Lewy condition of the evolution equation. In addition, we develop a partitioned-truncated singular value decomposition algorithm for the linear part of the inverse problem in the context of stochastic gradient descent. Numerical examples illustrate the efficacy of the proposed method, which turns out to have the capability of efficiently processing large-scale measurement data for the magnetic inverse problem. A possible generalization to the inverse problem of deep neural network is discussed at the end.

Neutral inclusions and weakly neutral inclusions

李晓菲

浙江工业大学

Abstract: An inclusion is said to be neutral to uniform fields if upon insertion into a homogenous medium with a uniform field it does not perturb the uniform field at all. It is said to be weakly neutral if it perturbs the uniform field mildly. Such inclusions are of interest in relation to invisibility cloaking and effective medium theory. There have been some attempts lately to construct or to show existence of such inclusions in the form of core-shell structure or a single inclusion with the imperfect bonding parameter attached to its boundary. This talk is to review recent progress in such attempts.

Scattering of waves in orthotropic elastic media

鲁汪涛

浙江大学

Abstract: In this talk, I will provide a high-accuracy boundary integral equation solver for wave scattering in orthotropic elastic media. Closed form of Green's tensor is derived based on the method of Fourier transform. A fast and accurate algorithm is developed to compute Green's tensor. We then solve the scattering problem based on a transparent boundary condition. Numerical examples demonstrate the accuracy of the solver.

Design and finite element simulation of information open electromagnetic cloak device

杨伟

湘潭大学

Abstract: In this talk, we first introduce the design principle and applications of the information open electromagnetic cloak device, and then we design two layered information open electromagnetic cloak devices based on linear and nonlinear transformations. By the finite element simulations, we find that the information open electromagnetic cloak device obtained by the level layered design method has better cloak effect than the equidistant layered design.

A hybrid boundary integral equation solver for wave equation problem in an interior domain

殷涛

中科院数学与系统科学研究院

Abstract: This talk will present a frequency-time hybrid solver for the time-dependent wave equation over a two-dimensional interior spatial domain. The approach relies on four main elements, namely, 1) A multiple scattering strategy that decomposes a given time-domain problem into a sequence of limited-duration time-domain problems of scattering by open-arcs, each one of which are reduced (by means of the Fourier transform) to a fixed sequence of frequency-domain problems; 2) "Spatially windowed" boundary integral equations on overlapping boundary patches (which do not suffer from solution singularity at the open-arc endpoints), for the solution of the frequency-domain problems in point 1); 3) A smooth "Time-windowing and recentering" methodology that enables both treatment of incident signals of long duration and long time simulation; and, 4) A Fourier transform algorithm that delivers numerically dispersionless, spectrally-accurate time evolution for given incident fields. Numerical examples will be presented which demonstrate the accuracy and efficiency of the proposed methodology.

An adaptive finite element DtN method for the elastic wave scattering problem in three dimensions

袁晓凯

吉林大学

Abstract: Consider the elastic scattering of an incident wave by a rigid obstacle in three dimensions, which is formulated as an exterior problem for the Navier equation. By constructing a Dirichlet-to-Neumann (DtN) operator and introducing a transparent boundary condition, the scattering problem is reduced equivalently to a boundary value problem in a bounded domain. The discrete problem with the truncated DtN operator is solved by using the a posteriori error estimate based adaptive finite element method. The estimate takes account of both the finite element approximation error and the truncation error of the DtN operator, where the latter is shown to converge exponentially with respect to the truncation parameter. Moreover, the generalized Woodbury matrix identity is utilized to solve the resulting linear system efficiently. Numerical experiments are presented to demonstrate the superior performance of the proposed method.

Mathematical theory for topological photonic materials in one dimension

张海

香港科技大学

Abstract: We present a rigorous theory for topological photonic materials in one dimension. The main focus is on the existence and stability of interface modes that are induced by topological properties of the bulk structure. For a general 1D photonic structure with time-reversal symmetry, we investigate the existence of an interface mode that is induced by a Dirac point upon perturbation. For a periodic photonic structure with both time-reversal and inversion symmetry, we show that corresponding topological index Zak phase is determined by the parity (even or odd) of the Bloch modes at the band edges. For a photonic structure consisting of two semi-infinite systems on the two sides of an interface with distinct topological indices, we show the existence of an interface mode inside the common gap. The stability of the mode under perturbations is also investigated.

M5：反散射问题和成像

（报告摘要按照姓氏拼音排序）

Visibility, invisibility and unique recovery of inverse electromagnetic problems with conical singularities

刁怀安

吉林大学

Abstract: Consider time-harmonic electromagnetic scattering in two scenarios, where the anomalous scatterer is either a pair of electromagnetic sources or an inhomogeneous medium, both with compact supports. In this talk, we are mainly concerned with the geometrical inverse scattering problem of recovering the support of the scatterer, independent of its physical contents, by a single far-field measurement. It is assumed that the support of the scatterer (locally) possesses a conical singularity. We establish a local characterisation of the scatterer when invisibility/transparency occurs, showing that its characteristic parameters must vanish locally around the conical point. Using this characterisation, we establish several local and global uniqueness results for the aforementioned inverse scattering problems, showing that visibility must imply unique recovery. In the process, we also establish the local vanishing property of the electromagnetic transmission eigenfunctions around a conical point under the Hölder regularity or a regularity condition in terms of Herglotz approximation.

Uniqueness and reconstruction method for inverse elastic wave scattering with phaseless data

董和平

吉林大学

Abstract: This talk concerns the inverse elastic scattering of an incident point source by an impenetrable obstacle with phaseless total-field data in two dimensions. To establish the uniqueness results, the reciprocity relation for point source and the mixed reciprocity relation are derived. Then, based on the infinite groups of incident fields superposed by two point sources at a fixed frequency, we prove the uniqueness result from the phaseless total-field data without knowing the boundary condition of the obstacle in advance. In addition, the uniqueness result from the phaseless far-field data is also obtained by using the infinite groups of incident fields superposed by a point source and a fixed plane wave. In order to reconstruct the shape and location of a rigid obstacle, a nonlinear integral equation based iterative algorithm is proposed by using the phaseless total-field data and a fixed incident point source. Numerical experiments are presented to show the effectiveness of the proposed algorithm.

Resonant modal approximation of time-domain elastic scattering from nano-bubbles in elastic materials

高忆先

东北师范大学

Abstract: This talk is devoted to establishing the resonant modal expansion of the low-frequency part of the scattered field for acoustic bubbles embedded in elastic materials in the time domain. Due to the nano-bubble with damping, Minnaert resonance can be induced at certain discrete resonant frequencies, which forms the fundamental basis of effectively constructing elastic metamaterials via the composite material theory. There are two major contributions in this work. First, we ansatz a special form of the density, approximate the incident field with a finite number of modes, and then obtain an expansion with a finite number of modes for the acoustic-elastic wave scattering in the time-harmonic regime. Second, we show that the low-frequency part of the scattered field in the time domain can be well approximated by using the resonant modal expansion with sharp error estimates. Interestingly, we find that the 0-th mode is the main contribution to the resonant modal expansion.

Variational Inverting Network for Statistical Inverse Problems of Partial Differential Equations

贾骏雄

西安交通大学

Abstract: For quantifying the uncertainties of the inverse problems governed by some partial differential equations (PDEs), the inverse problems are transformed into statistical inference problems based on Bayes' formula. Recently, infinite-dimensional Bayesian analysis methods are introduced to give a rigorous characterization and construct dimension-independent algorithms. However, there are three major problems for current infinite-dimensional Bayesian methods: prior measures usually only behaves like regularizers; complex noises are rarely considered; many computationally expensive forward PDEs need to be calculated for estimating posterior statistical quantities. To address these issues, we propose a general infinite-dimensional inference framework based on a detailed analysis on the infinite-dimensional variational inference method and the ideas of deep generative models that are popular in the machine learning community. Specifically, by introducing some measure equivalence assumptions, we derive the evidence lower bound in the infinite-dimensional setting and provide possible parametric strategies that yield a general inference framework named variational inverting network (VINet). This inference framework has the ability to encode prior and noise information from learning examples. In addition, relying on the power of deep neural networks, the posterior mean and variance can be efficiently generated in the inference stage in an explicit manner. In numerical experiments, we design specific network structures that yield a computable VINet from the general inference framework. Numerical examples of linear inverse problems governed by a Helmholtz equation are given, illustrating the effectiveness of the proposed inference framework.

Minnaert resonances for bubbles in soft elastic materials

李宏杰

香港中文大学

Abstract: In this talk, the low-frequency resonance for acoustic bubbles embedded in soft elastic materials is discussed. This is a hybrid physical process that couples the acoustic and elastic wave propagations. By delicately and subtly balancing the acoustic and elastic parameters as well as the geometry of the bubble, we show that Minnaert resonance can occur for rather general constructions. This study poses a great potential for the effective realisation of negative elastic materials by using bubbly elastic media.

Fixed angle inverse scattering for sound speeds close to constant

马世琪

吉林大学

Abstract: We study the fixed angle inverse scattering problem of determining a sound speed from scattering measurements corresponding to a single incident wave. The main result shows that a sound speed close to constant can be stably determined by just one measurement. Our method is based on studying the linearized problem, which turns out to be related to the acoustic problem in photoacoustic imaging. We adapt the modified time-reversal method from [P. Stefanov and G. Uhlmann, Thermoacoustic tomography with variable sound speed, Inverse Problems 25 (2009), 075011] to solve the linearized problem in a stable way, and we use this to give a local uniqueness result for the nonlinear inverse problem.

Effective Medium Theory for Embedded Obstacles in Elasticity with Applications to Inverse Problems

孟庆乐

香港城市大学

Abstract: In this talk, we mainly consider a time-harmonic elastic wave scattering from a general inhomogeneous medium with an embedded impenetrable obstacle, which is strongly motivated by the partial-data inverse boundary problem and the inverse scattering problem of recovering complex scatterers consisting of mediums and buried obstacles. We first explore the scattering model with embedded obstacle can be effectively approximated by a scattering model with an isotropic elastic medium with particular material parameters, then we derive a sharp estimate to rigorously verify such an effective approximation. This result in this talk is joint works with Zhengjiang Bai(XMU), Huaian Diao(JLU) and Hongyu Liu(CityU)

Geometrical properties of transmission eigenfunctions

汪贤超

哈尔滨工业大学

Abstract: In this talk, we present the discovery of a novel and intriguing global geometric structure of the (interior) transmission eigenfunctions associated with the Helmholtz system and Maxwell system, respectively. It is shown in generic scenarios that there always exists a sequence of transmission eigenfunctions with the corresponding eigenvalues going to infinity such that those eigenfunctions are localized around the boundary of the domain. We provide a comprehensive and rigorous justification in the case within the radial geometry, whereas for the non-radial case, we conduct extensive numerical experiments to quantitatively verify the localizing behaviors. The discovery provides a new perspective on wave localization.

Convergence analysis of the Yee scheme on non-uniform grids for 3D Maxwell's equations with the uniaxial PML

张波

中科院数学与系统科学研究院

Abstract: A new kind of perfectly matched layer (PML) methods was proposed recently for 3D time-domain electromagnetic scattering problems (SIAM J. Numer. Anal. 58(3) (2020), 1918-1940: the spherical PML; arXiv:2102.01843v1, 2021: the uniaxial PML). It has been proved that this kind of PML methods is exponentially convergent in terms of the layer thickness and the PML parameters. In this paper, we further study the energy variation of the electromagnetic fields for the truncated problem with the new uniaxial PML covered by a perfectly conducting condition (PEC) on the outer boundary of the PML layer (called the truncated PML problem in this paper) and the convergence of the Yee scheme on non-uniform grids for the truncated PML problem. It is proved that the truncated PML problem is energy conserved in terms of the energy of the electromagnetic fields and their curls. By the energy identity, the stability condition for the Yee scheme on non-uniform grids is derived, and then the stability as well as the superconvergence of the Yee scheme on non-uniform grids are proved in terms of the discrete L^2 norm. Numerical experiments are also conducted to confirm the analysis of the Yee scheme and the practical efficiency of the new PML method. This talk is based on recent joint work with Liping Gao.

单调算子方法求解反位势问题

张植栋

中山大学珠海校区

Abstract: 本报告考虑抛物方程中的反位势问题，所用数据为最终时刻观测。首先我们从方程和观测数据出发，构造一个以未知位势项为不动点的算子。然后对于此算子，我们证明了其单调性，并从单调性出发得到了反问题的唯一性以及数值迭代算法。在数值部分，我们给出了一个误差估计并使用一些算例来验证所得结论。

Inverse obstacle scattering for elastic waves in the time domain

赵璐

吉林大学

Abstract: This talk concerns an inverse elastic scattering problem which is to determine a rigid obstacle from time domain scattered field data for a single incident plane wave. By using Helmholtz decomposition, we reduce the initial-boundary value problem of the time domain Navier equation to a coupled initial-boundary value problem of wave equations, and prove the uniqueness of the solution for the coupled problem by employing energy method. The retarded single layer potential is introduced to establish the coupled boundary integral equations, and the uniqueness is discussed for the solution of the coupled boundary integral equations. Based on the convolution quadrature method for time discretization, the coupled boundary integral equations are reformulated into a system of boundary integral equations in s-domain, and then a convolution quadrature based nonlinear integral equation method is proposed for the inverse problem. Numerical experiments are presented to show the feasibility and effectiveness of the proposed method.

An interior inverse scattering problem in elasticity

曾芳

重庆大学

Abstract: We consider an interior inverse scattering problem of reconstructing the shape of an elastic cavity. First of all, we show a reciprocity relation for the scattered elastic field and a uniqueness theorem for the inverse problem. Then we employ the decomposition method to determine the boundary of the cavity and present some convergence results. Numerical examples are provided to show the viability of the method.

Fast inference for restricted maximum likelihood methods with linear mixed models

朱圣鑫

北师港浸大

Abstract: Variance parameters estimation is one of the most important problems in statistical inference. In this talk, we shall introduce the information splitting technique and show how to combine such a splitting idea with some matrix analysis to design fast solvers for large scale variance parameter estimation in the linear mixed models.

M6：数学物理方程及其反问题的理论与算法

（报告摘要按照姓氏拼音排序）

Spatiotemoral Imaging with Diffeomorphic Optimal Transportation

陈冲

中国科学院数学与系统科学研究院

Abstract: Motivated by the image reconstruction in spatiotemporal imaging, we introduce a concept named diffeomorphic optimal transportation (DOT), which combines the Wasserstein distance with Benamou--Brenier formula in optimal transportation and the flow of diffeomorphisms in large deformation diffeomorphic metric mapping. Using DOT, we propose a new variational model for joint image reconstruction and motion estimation, which is suitable for spatiotemporal imaging involving mass-preserving large diffeomorphic deformations. The proposed model is easy-to-implement and solved by an alternating gradient descent algorithm, which is compared against existing alternatives theoretically and numerically. Moreover, we present more extensions with applications to spatiotemporal imaging and image registration based on DOT. Under appropriate conditions, the proposed algorithm can be adapted as a new algorithm to solve the models using quadratic Wasserstein distance. The performance is validated by several numerical experiments in spatiotemporal tomography, where the projection data is time-dependent sparse and/or high-noise.

Inverse source problems for the stochastic wave equations: far-field patterns

李建樑

湖南师范大学

Abstract: This talk addresses the direct and inverse source problems for the stochastic acoustic, biharmonic, electromagnetic, and elastic wave equations in a unified framework. The driven source is assumed to be a centered generalized microlocally isotropic Gaussian random field, whose covariance and relation operators are classical pseudodifferential operators. Given the random source, the direct problems are shown to be well-posed in the sense of distributions and the regularity of the solutions are given. For the inverse problems, we demonstrate by ergodicity that the principal symbols of the covariance and relation operators can be uniquely determined by a single realization of the far-field pattern averaged over the frequency band with probability one.

Direct imaging method for reconstructing penetrable locally rough surfaces from phaseless total-field data

李隆

中国科学院数学与系统科学研究院

Abstract: This paper is concerned with the problem of inverse scattering of time-harmonic acoustic plane waves by a two-layered medium with a locally rough interface in 2D. A direct imaging method is proposed to reconstruct the locally rough interface from the phaseless total-field data measured on the upper half of the circle with a large radius at a fixed frequency. The presence of the locally rough interface poses challenges in the theoretical analysis of the imaging methods. To address these challenges, a technically involved asymptotic analysis is provided for the relevant oscillatory integrals involved in the imaging method, based mainly on the techniques and results in our recent work [L. Li, J. Yang, B. Zhang and H. Zhang, arXiv:2208.00456] on the uniform far-field asymptotics of the scattered field for acoustic scattering in a two-layered medium. Finally, extensive numerical experiments are conducted to demonstrate the feasibility and robustness of our imaging algorithm.

Direct reconstruction methods in the ocean waveguide

刘可伋

上海财经大学

Abstract: The scattering problems of marine acoustics have attracted great attention in recent years since they have wide applications in identifications of submarines, mineral deposits, wreckages, reef, submerged scatterers, etc. In this talk, we shall present the inverse problems and the corresponding direct reconstruction methods in the ocean waveguide. The direct reconstruction methods can be viewed as simple and efficient numerical techniques for providing reliable initial approximate locations of the marine sources and scatterers for any existing more refined and advanced but computationally more demanding algorithms to recover the accurate physical profiles.

An Accelerated Level-Set Method for Inverse Scattering Problems

刘晓莉

北京航空航天大学

Abstract: In this talk, we propose a rapid and robust iterative algorithm to solve inverse acoustic scattering problems formulated as a PDE constrained shape optimization problem. We use a level-set method to represent the obstacle geometry and propose a new scheme for updating the geometry based on an adaptation of accelerated gradient descent methods. The resulting algorithm aims at reducing the number of iterations and improving the accuracy of reconstructions. To cope with regularization issues, we propose a smoothing to the shape gradient using a single layer potential associated with ik where k is the wave number. Numerical experiments are given for several data types (full aperture, backscattering, phaseless, multiple frequencies) and show that our method outperforms a nonaccelerated approach in terms of convergence speed, accuracy, and sensitivity to initial guesses.

Simultaneously imaging a conductive medium and various obstacles

曲风龙

烟台大学

Abstract: This report intends to introduce the inverse problem of scattering of time-harmonic acoustic waves by a mixed-type scatterer, which is the union of a conductive inhomogeneous penetrable medium and impenetrable obstacles with various boundary conditions. We aim to develop a modified factorization method to show that both the support of the inhomogeneous medium and the shape and location of the impenetrable obstacle can be simultaneously reconstructed by means of the far-field data. Numerical examples are presented to illustrate the feasibility and effectiveness of the proposed inversion algorithms.

Inverse problems of magnetic resonance electrical impedance tomography based on a single measurement

宋义壮

山东师范大学

Abstract: Magnetic resonance electrical impedance tomography (MREIT) aims to reconstruct the conductivity distribution of an imaging object using a partial information of magnetic flux densities which can be measured through an MRI scanner. Its capability of providing a high spatial resolution conductivity image is unique. Traditional MREIT reconstructions takes use of two data sets produced by two linearly independent currents. However, the temporal resolution of the reconstructed images is low. Moreover, it seems cubersome in some real clinical applications such as transcranial electrical stimulation. Recently, we propose an iterative reconstruction algorithm, called the single current harmonic B_z algorithm which can produce a conductivity image using only half of the time compared with the traditional reconstructions. In this paper, we provide a rigous mathematical analysis for the convergence of the single current harmonic B_z algorithm. It turns out that under some mild condition of the true conductivity, the sequences produced by the single current harmonic B_z algorithm convergent exponentially to the true solution ($\ln$ of the conductivity). We do numerical simulations to validate the proposed theory.

An introduction to the time-domain PML method for wave scattering problems

魏昌坤

北京交通大学

Abstract: In this talk, I firstly introduce briefly the main theoretical and numerical results on the time-domain scattering problems, especially focusing on the time-domain perfectly matched layer (PML) method. Then I will report a recent work on the PML analysis for the 3D time-domain electromagnetic scattering problems. The exponential convergence of the PML method is established in terms of the thickness of the layer and the PML parameter. As far as we know, this is the first convergence result for the time-domain PML method for the 3D Maxwell equations. Our proof is mainly based on the stability estimates of solutions of the truncated PML problem and the exponential decay estimates of the stretched dyadic Green's function for the Maxwell equations in the free space.

Direct and inverse scattering by unbounded penetrable rough surfaces

吴承宇

西安交通大学

Abstract: This talk concerns the direct and inverse scattering problem by an unbounded penetrable rough surface in a lossless medium. The cases that the transmission coefficient $\mu\neq1$ and $\mu=1$, which creates certain difficulties in the direct and inverse problem, respectively, are both considered. We first estalish the well-posedness of the direct problem using the integral equation method. Then we carefully consider the singularity of the solutions to the problem with incident point source or hypersingular point source, where a simple and novel perspective is given for the derivation of the singularity. Finally, a global uniqueness result is proven for the inverse problem on the unique determination of the unbounded rough surface, the transmission coefficient and the wave number in the lower half plane from the measurements of the near field only on a line segment above the interface at a fixed frequency.

Uniqueness to inverse grating diffraction problem with infinitely many plane waves at a fixed frequency

徐小绪

西安交通大学

Abstract: In this talk, we focus on the inverse grating diffraction problem in two dimensional case. We prove that a sound-soft periodic curve can be uniquely determined by the near-field data of infinitely many incident plane waves with distinct directions at a fixed frequency. Our proof is based on Schiffer's idea which consists of two ingredients: i) the total fields incited by distinct incident directions are linearly independent; ii) there exist only finitely many linearly independent Dirichlet eigenfunctions in a bounded domain or in a closed waveguide under additional assumptions on the waveguide boundary. Based on the Rayleigh expansion, we show that the phased near-field data can be uniquely determined by the phaseless near-field data in a bounded domain, with the exception of a finite set of incident angles. Such a phase retrieval result leads to new uniqueness results using the near-field data without phase information. This talk is based on a joint work with Guanghui Hu, Bo Zhang, and Haiwen Zhang.

M7：正则化算法及应用

（报告摘要按照姓氏拼音排序）

Tikhonov regularizations with Lp penalties

陈德汗

华中师范大学

Abstract: This talk presents the new trends and recent developments of Tikhonov regularizations in Hilbert and Banach settings. We first present classical results of VSC in Hilbert settings. Then, we propose and analyze variational source conditions (VSC) for the Tikhonov regularization methods with Lp-penalties applied to an ill-posed operator equation in a Banach space. Our analysis is built on the celebrated Littlewood-Paley theory and the concept of l^2-boundedness. With these two analytical principles, we validate the proposed VSC under a conditional stability estimate in terms of a dual Triebel-Lizorkin-type norm. On the other hand, we will presents the applications of VSCs in some inverse PDEs problems.

Second-order flows as computational models for inverse problems and beyond

董国志

中南大学

Abstract: We introduce second-order flows as computational models for the solutions of problems arising from inverse problems, mathematical imaging and beyond. This is a recent topic inspired by second-order dynamics in convex optimization, while we focus on regularization properties, partial differential equation settings, and non-convex constrained problems.

Convergence analysis of a generalized Levenberg-Marquardt method for possibly non-smooth inverse problems

付振武

哈尔滨工业大学

Abstract: In this work, we propose a generalized Levenberg-Marquardt method for nonlinear inverse problems. Compared with the conventional Levenberg-Marqurdt method, the proposed method could be independent of the Fréchet derivative of forward operator F and the iteration points. So it can be used to solve both smooth and non-smooth inverse problems. This method is also designed with general convex penalty terms to detect special features of solutions such as sparsity and piecewise constancy. Convergence analysis of this method is established under a general tangential cone condition (GTCC). In addition, we derive the convergence rate of the proposed method under Hölder-type stability condition. As byproduct, we prove that the general tangential cone condition holds for some PDE inverse problems. Finally, numerical simulations are presented to show the efficiency of the proposed method.

A Fast Data-Driven Iteratively Regularized Method with Convex Penalty for Solving Ill-Posed Problems

郜广宇

哈尔滨工业大学

Abstract: In this work, we propose a new iterative regularization method for solving inverse problems in Hilbert spaces. The iterative process of the proposed method combines classical iterative regularization format and Data-Driven approach. Data-Driven technique is based on the idea of deep learning to estimate the interior of a black box through a training set, so as to solve problems better and faster in some cases. In order to capture the special feature of solutions, convex functions are utilized to be penalty terms. Algorithmically, the two-point gradient acceleration strategy based on homotopy perturbation method is applied to the iterative scheme, which makes the method have satisfactory acceleration effect. We provide convergence analysis of the method under standard assumptions for iterative regularization methods. Finally, several numerical experiments are presented to show the effectiveness and acceleration effect of our method.

Heuristic rule for inexact Newton-Landweber iteration with convex penalty terms of nonlinear ill-posed problems

谷瑞雪

大连海事大学

Abstract: Inexact Newton regularization is a family of prominent regularization methods for solving nonlinear ill-posed problems, which consists of an outer Newton iteration and an inner scheme providing increments by applying the regularization technique to the local linearized equations. In this paper, we propose a heuristic stopping rule for inexact Newton regularization, where the inner scheme is defined by Landweber iteration and the strong convex function is incorporated as the penalty term. In contrast to a prior and a posteriori stopping rules, our heuristic rule is purely data driven and does not require the information on noise level, which renders the method feasible when the noise level is unknown or unreliable. Under certain assumptions on the random noise, we establish a new convergence analysis for the inexact Newton-Landweber method under the heuristic rule. The numerical simulations are provided to demonstrate the performance of our heuristic rule.

Fluid Velocity Reconstruction by a Deep Neural Network Approximating Variational Data Assimilation

李龙

哈尔滨工业大学

Abstract: Current machine learning-driven methods make a positive difference to outlook on data assimilation. However, its reliability remains to be studied since little deterministic information from physical laws is involved. In this talk, we will introduce our recent work about the efficient assimilation of image sequences into mathematical models by the approximation of a deep neural network (DNN). A novel minimizing loss function that guarantees the estimations from the equations and the neural network consistent with the observations was established. Combined with the image model, data assimilation inverse problem can be regarded as forward modelling in a DNN framework. Thus the dimension of the variable to be determined will reduce, so is the huge computational cost for the identification of time-dependent model coefficient. The sparsity regularization that accounts for sharp fronts was employed to improve the well-posedness. Assimilation results show the proposed method is robust for reconstructing the surface velocity of a fluid with vortex structures, which is a common and important issue in oceanic forecasting.

An Investigation on Semismooth Newton based Augmented Lagrangian Method for Image Restoration

孙鸿鹏

中国人民大学

Abstract: The augmented Lagrangian method (also called as method of multipliers) is an important and powerful optimization method for lots of smooth or nonsmooth variational problems in modern signal processing, imaging and optimal control. However, one usually needs to solve a coupled and nonlinear system of equations, which is very challenging. In this paper, we propose several semismooth Newton methods to solve arising nonlinear subproblems for image restoration in finite dimensional spaces, which leads to several highly efficient and competitive algorithms for imaging processing. With the analysis of the metric subregularities of the corresponding functions, we give both the global convergence and local linear convergence rate for the proposed augmented Lagrangian methods with semismooth Newton solvers.

Dual gradient method for ill-posed problems using multiple repeated measurement data

王薇

嘉兴学院

Abstract: We consider determining $\R$-minimizing solutions of linear ill-posed problems $A x = y$, where $A: \X \to \Y$ is a bounded linear operator from a Banach space $\X$ to a Hilbert space $\Y$ and $\R: \X \to [0, \infty]$ is a proper strongly convex penalty function. Assuming that multiple repeated independent identically distributed unbiased data of y are available, we consider a dual gradient method to reconstruct the $\R$-minimizing solution using the average of these data. By terminating the method by either an {\it a priori} stopping rule or a variant of the discrepancy principle, we provide the convergence analysis and derive convergence rates when the sought solution satisfies certain variational source conditions. Various numerical results are reported to test the performance of the method.

Convergence analysis of inexact Newton-Landweber iteration under H\"{o}lder stability

夏宇欣

哈尔滨工业大学

Abstract: In this work, we focus on a class of inverse problems with Lipschitz continuous Fr\'{e}chet derivatives both in Hilbert spaces and Banach spaces. The convergence and convergence rate of the inexact Newton-Landweber method (INLM) for such problems are presented under some assumptions. For the inverse problems in Hilbert spaces, we revisit the convergence result and the convergence rate of the INLM under Lipschitz condition and H\"{o}lder stability. Furthermore, the INLM for nonlinear inverse problems in Banach spaces is also considered. By using a H\"{o}lder stability corresponding to the Bregman distance, we derive the convergence property and convergence rate of the method.

Estimating the memory parameter for possibly non-linear and non-Gaussian time series with wavelets

徐晨

深圳北理莫斯科大学

Abstract: The asymptotic theory for the memory parameter estimator constructed from log-regression with wavelets is incomplete for 1/f processes that are not necessarily Gaussian or linear. Such a theory is necessary due to the importance of non-Gaussian and nonlinear long memory models in describing financial time series. To fill this gap, we prove that under an assumption which can be implied by ergodicity and additional ones, the estimator is asymptotically consistent.

M8：随机反问题与不确定性量化

（报告摘要按照姓氏拼音排序）

Theoretical analysis and numerical reconstruction for three kinds of inverse random problems

冯晓莉

西安电子科技大学

Abstract: The inverse problem of stochastic differential equations is a new branch and an important research field of inverse problems. It is full of challenges because it involves the ill-posedness of inverse problems and the low regularity and uncertainty of random noise. Given a stochastic differential equation, in what sense does its solution exist, and how to find appropriate statistics to reconstruct the random function described by statistical data are the core issues of the stochastic inverse problem. This talk is about the time-fractional differential equation driven by fractional Brownian motion from the theoretical analysis, reconstruction algorithm design and effective implementation of three kinds of inverse problems: inverse random initial data, inverse random source and inverse random potential. For different random fields, it is proposed to give the well-posedness and corresponding stability estimates of the corresponding stochastic direct problem; For the corresponding inverse random problem, the effective reconstruction formula between the statistics of the random function to be inverted and the observed data will be established, and the corresponding existence, uniqueness results and stability analysis will be given; Combining the regularization method and the preconditioned iterative algorithm, we will study the efficient algorithm in different random situations.

Current density impedance imaging with PINNs

焦雨领

武汉大学

Abstract: In this paper, we introduce CDII-PINNs, a computationally efficient method for solving CDII using PINNs in the framework of Tikhonov regularization. This method constructs a physics-informed loss function by merging the regularized least-squares output functional with an underlying differential equation, which describes the relationship between the conductivity and voltage. A pair of neural networks representing the conductivity and voltage, respectively, are coupled by this loss function. Then, minimizing the loss function provides a reconstruction. We give an error analysis for CDII-PINNs and establish a convergence rate, based on prior selected neural network parameters in terms of the number of samples. The numerical simulations demonstrate that CDII-PINNs are efficient, accurate and robust to noise levels ranging from 1% to 20%.

Inverse random potential scattering for elastic waves

李建樑

湖南师范大学

Abstract: This talk is concerned with the inverse scattering for a random source/potential, where the source/potential is assumed to be microlocally isotropic generalized Gaussian random field such that its covariance operator is a classical pseudo-differential operator. For such a distributional source/potential, we show that the direct scattering problem admits a unique solution in the sense of distribution. For the inverse scattering problem, we demonstrate that the principle symbol of the covariance operator can be uniquely determined with probability one by the high frequency limit of the averaged near-field or far-field data obtained form a single path of the random source/potential.

Scattering and Inverse Scattering by a Random Periodic Structure

林怡雯

上海交通大学

Abstract: Consider the scattering of a time-harmonic electromagnetic plane wave by a random periodic structure. An efficient numerical method is proposed for solving the inverse scattering problem by a random periodic perfectly reflecting structure. More specifically, our method is based on a novel combination of the Monte Carlo technique for sampling the probability space, a continuation method with respect to the wavenumber, and the uncertainty quantification for the random structure using Karhunen-Loève expansion, which reconstructs all key statistics of the profile for the unknown random periodic structure from boundary measurements of the scattered fields away from the structure. Numerical results will be presented to demonstrate the reliability and efficiency of the proposed method. Furthermore, we will show the well-posedness and a priori bounds on the solution of the Helmholtz equation on random periodic Lipschitz structures. The talk is based on a joint work with G. Bao and X. Xu.

A low-rank approximated multiscale method for PDEs with random coefficients

欧娜

长沙理工大学

Abstract: This work presents a stochastic multiscale model reduction approach to solve PDEs with random coefficients. An ensemble-based low-rank approximation method is proposed to approximate multiscale basis functions used to build a coarse model. To this end, we build local problems with multiple boundary conditions based on the generalized multiscale finite element method (GMsFEM), and construct a variable-separation representation for the corresponding multiscale basis functions, which admits a low-rank approximated form in terms of stochastic basis functions and deterministic physical basis functions. The construction and interrogation of the low-rank approximation for each multiscale basis function may demand fair computational cost. To significantly improve the efficiency of computation in the offline and interrogating the low-rank representation in the online stage, the ensemble-based method is proposed. In the offline stage, we obtain the stochastic basis functions and interpolate points using a variable separation method, with respect to the ensemble equation, then derive the deterministic physical parts for each member of the ensemble through residual decomposition. The resulted low-rank representations for each member share the common stochastic basis functions but have different physical basis functions characterizing their individual properties, offering considerable savings in online computation. This approach provides much flexibility inherited from GMsFEM and derives an efficient surrogate model. We present various numerical examples to demonstrate the accuracy and efficiency of the proposed method.

Multi-fidelity deep learning method for the inversion of force function in PDEs

王洪桥

中南大学

Abstract: In this work, we focus on a typical inversion problem derived from parametric partial differential equations (PDEs). Our aim is to estimate the force function term from the noisy measurements of the PDE solution at some sparse input points. Traditional methods for the inversion require a large amount calls of the refined PDE solver, which is computationally intensive in the challenging PDE problem, and therefore the inference of the force function would be intractable. Here, we propose a multi-fidelity method which combines the coarse and refined solvers to efficiently infer the posterior of the force function. The computational intensive PDE solver is replaced by a combination of a cheap coarse PDE solver and a neural network-based map which maps the transformation between the coarse PDE solution and the refined one. Approximate Bayesian computation method is used for constructing an informative data-set for the transformation learning. Preconditioned Crank-Nicolson Markov chain Monte Carlo method is used for drawing the samples of the posterior its effectiveness is shown in numerical examples.

Stochastic inverse source problems for fractional diffusion equations

王旭

中科院科学院数学与系统科学研究院

Abstract: In this talk, the inverse random source problem for a stochastic time fractional diffusion equation is introduced, where the source is assumed to be driven by a Gaussian random field. The direct problem is shown to be well-posed by examining the well-posedness and regularity of the solution for the equivalent stochastic two-point boundary value problem in the frequency domain. For the inverse problem, the Fourier modulus of the diffusion coefficient of the random source is proved to be uniquely determined by the variance of the Fourier transform of the boundary data. As a phase retrieval for the inverse problem, the PhaseLift method with random masks is applied to recover the diffusion coefficient from its Fourier modulus. Several numerical experiments are also reported to demonstrate the effectiveness of the proposed method.

Linearized Inverse Potential Problems at a High Frequency

许伯熹

上海财经大学

Abstract: We investigate recovery of the potential function from many boundary measurements at a high frequency for linear or nonlinear equations. By considering such a linearized form, we obtain Hölder type stability which is a big improvement over logarithmic stability in low frequencies. Increasing stability bounds for these coefficients contain a Lipschitz term with a factor growing polynomially in terms of the frequency, a Hölder term, and a logarithmic term which decays with respect to the frequency as a power. Based on the linearized problem, a reconstruction algorithm is proposed aiming at the recovery of sufficiently many Fourier modes of the potential function. By choosing the high frequency appropriately, the numerical evidence shed light on the influence of the growing frequency and confirms the improved resolution. This is the joint work with Prof. Victor Isakov, Prof. Shuai Lu, Prof. Mikko Salo and Mr. Sen Zou.

Mathematical analysis for composite scattering in multilayered mediums

张磊

浙江工业大学

Abstract: Electromagnetic wave interactions with the interface of a medium and obstacles within it is a critical issue with many applications in diverse fields such as remote sensing, nondestructive testing, geophysics, national defense, and military. In this talk, we focus on the mathematical analysis and numerical methods for composite scattering in multilayered mediums. Both the time-harmonic and time-domain problems of composite scattering are considered. The time-harmonic problem deals with the interaction of electromagnetic waves with a multilayered medium at a fixed frequency. In contrast, the time-domain problem involves the study of the transient behavior of electromagnetic waves in the medium, where the frequency varies with time. Both of these problems have applications in different fields.

M9：复杂过程辨识方法研究及工程应用

（报告摘要按照姓氏拼音排序）

The springback penalty for robust signal recovery

安聪沛

西南财经大学

Abstract: We propose a new penalty, the springback penalty, for constructing models to recover an unknown signal from incomplete and inaccurate measurements. Mathematically, the springback penalty is a weakly convex function. It bears various theoretical and computational advantages of both the benchmark convex 1 penalty and many of its non-convex surrogates that have been well studied in the literature. We establish the exact and stable recovery theory for the recovery model using the springback penalty for both sparse and nearly sparse signals, respectively, and derive an easily implementable difference-of-convex algorithm. In particular, we show its theoretical superiority to some existing models with a sharper recovery bound for some scenarios where the level of measurement noise is large or the amount of measurements is limited. We also demonstrate its numerical robustness regardless of the varying coherence of the sensing matrix. The springback penalty is particularly favorable for the scenario where the incomplete and inaccurate measurements are collected by coherence-hidden or -static sensing hardware due to its theoretical guarantee of recovery with severe measurements, computational tractability, and numerical robustness for ill-conditioned sensing matrices.

电力设备多物理场反问题求解技术与工程应用

程建伟

南方电网科学研究院有限责任公司

Abstract: 针对电力装备投运后的故障分析、状态评估、内特性可视化等代表性反问题模拟，开展技术路线、研究工具、仿真方法和分析要素研究，介绍南方电网设备多物理场代表性反问题的工程仿真实践。

A WENO finite volume method based on radial basis function for hyperbolic conservation laws

甘文勇，叶颀

华南师范大学

Abstract: In this talk, we will propose the use of radial basis functions (RBF) instead of polynomial in ENO or WENO finite volume methods in order to solve hyperbolic conservation laws, which is more suitable for free mesh. In WENO reconstruction, we show that optimizing the value of parameter of the radial basis functions interpolation (such as multi-quadratic, Gaussian RBF) provides a way to further improve the performance of WENO reconstruction, which can control the local error. A collection of Numerical results shows that radial basis functions WENO finite volume methods has higher local accuracy, more effective in resolving shocks and other complex solution structures.

基于端到端卷积的生成对抗网络求解器在生物传热反问题中的应用

黄明鸣、韩熠南、古江杭

中山大学

Abstract: 生物传热领域是传热学和生命科学、医学交叉的前沿研究领域。在生物传热过程中，生物体表温度场信息可通过红外摄像机捕捉，边界条件如热流密度等可通过传热规律计算获得，然而生物体内的热源、血灌率等理化信息难以获取。目前获取生物组织内信息多用有损测量方法，仅能测量有限个数据点，如何实现生物体的动态无损检测是亟需解决的问题。因此，基于可测的生物体表温度无损重构生物体内理化信息作为一个不适定生物传热反问题，备受学界的关注，同时具有极其重要的临床意义。

本工作提出一种基于端到端卷积的生成对抗网络方法，反演重构生物内热源信息，探究生物的未知传热机理。该方法使用由多层卷积与反卷积算子组成的生成模型来逼近基于 Pennes 描述的生物传热方程的反演算子，通过预设内热源的可靠正演数值模拟生成训练数据，用于生成对抗网络的博弈学习，以提高模型的预测准确性，随后对真实数据进行端到端的反演识别得到最终结果。为验证该求解器的有效性，本工作以选定小尺度生物物种为研究对象，反演获取相关物种活体状态下的内热源变化，探究生物体温度调控机制。与传统实验方法相比，本工作基于端对端卷积生成对抗网络求解器的方法，可利用生物体红外测温数据反演获得生物内热源等重要信息，实现了生物体内信息的无损测量，降低了测量成本；与传统反问题正则化求解策略相比，本文所提出的求解器计算效率达毫秒级别，同时适用于求解非线性瞬态的生物复杂系统中的传热现象，有望被应用于攻关生物医学应用中的实时无损软测量关键技术。

A fast algorithm for solving boundary integral equations on domain with corners

江颖

中山大学

Abstract: In this talk we will introduce our recent works for solving the boundary integral equation derived from the Dirichlet problem of Laplace equation in a domain with corners. It is well known that the integral operator in the equation can be split into two operators, one is non-compact, the other is compact. We design two truncation strategies for the representation matrices of these operators, respectively, which compress these two dense matrices to sparse ones having only O(2n) number of nonzero entries, where 2n is the number of the wavelet basis functions used in the method. We prove that the proposed truncation strategies do not ruin the stability and convergence rate of the integral equation. Numerical experiments are presented to verify the theoretical results and demonstrate the effectiveness of the method.

基于机理与数据融合的复杂 PDE 系统逆向设计与应用

罗玖、 黄启贤

中山大学、太原理工大学

Abstract: 复杂多尺度、多物理场耦合工程应用场景下的非线性偏微分方程系统逆向设计问题具有研究挑战性。数据驱动与机理模型驱动结合提供了新的研究思路。本团队近期采用机理与数据的融合计算方法结合高性能计算开展 HPC+AI for Science 新科学范式研究，并成功应用于海水反渗透淡化系统多尺度逆向设计基准案例中。该工作首先对大量不同工况三维多物理场耦合计算流体动力学（Computational Fluid Dynamics, CFD）模型进行参数化建模，并基于“天河二号”超算平台进行高通量并行计算，计算规模可扩展至约 10 万核，较串行算法计算效率提升超过 3000 倍，可大幅度缩短设计周期。进一步使用机器学习处理 CFD 模拟数据建立高维表征代理模型，对复杂高维非线性映射进行逼近。最后通过智能优化算法对建立的数据与机理融合混合模型约束的混合整数非线性规划问题进行高效求解，获得反渗透膜组件与系统多尺度逆向设计方案。该研究中采用的 HPC+AI for Science 研究思路已在能源与资源、材料与化工、工业与制造、环境与大气、生物医工等科学与工程交叉领域展开系列应用。

贝叶斯蒙特卡罗方法在三维瞬态热传导反问题求解中的应用

王晨、谢雨露、杨青青

中山大学、南开大学、中山大学

Abstract: 由偏微分方程控制的连续系统反问题在许多科学和工程领域都有重要的应用，如钢淬火、池沸腾等，从已获取的连续场测量数据中确定未知的边界条件、初始条件、物理参数或几何形状等。这些已知的信息通常是给定空间和时间位置的离散及含噪音实验数据，因此，大多数反问题本质上是数据驱动的，这就造成了反问题的不适定性以及求解的高成本性。
传统的 Tikhonov 正则化方法以及其衍生方法被广泛用于解决反问题的不适定性，而通过贝叶斯先验约束也可以实现此类方法的替代。我们提出了一个反问题算法框架，该框架集成了贝叶斯统计理论和多维蒙特卡罗采样技术。贝叶斯计算方法在许多方面具有优势，特别是，它能够量化系统的不确定性和随机数据误差，给出反问题解空间的概率描述，为反问题的不适定性提供灵活的空间、时间正则化，并允许自适应序列估计。该计算框架利用马尔可夫随机场(MRF)先验概率模型对未知量进行先验建模，通过贝叶斯推理建立了未知量的后验概率密度(PPDF)，并且采用蒙特卡罗算法进行抽样估计。此算法框架具有通用性，适用于求解包括热传导、热对流、热辐射等一系列传热反问题。该方法的可行性和准确性通过具有代表性的数值案例计算得到验证。基于贝叶斯理论的蒙特卡罗方法可以提供此类反问题的高精度数值解，为相关工程领域的应用提供理论依据和技术参考。

一个求解粘弹性动力多宗量辨识反问题的数值方法

于洋、何宜谦、王崇帅、杨海天

大连理工大学

Abstract: 提出一个求解粘弹性动力多宗量辨识反问题的数值算法。利用时域分段自适应算法（TPAA）和比例边界元法（SBFEM），建立了考虑第三类边界条件(TKBC)的粘弹性动力正问题的求解模型。TPAA 可在不同步长下保证解的时域计算精度； SBFEM 可方便处理应力奇异性问题、多边形和四叉树比例边界有限单元可有效提高网格剖分的便捷性。建立了基于敏度分析的反问题求解模型，并基于正问题求解模型提出了一个相关敏度计算的递推自适应算法。采用 Levenberg-Marquardt 方法求解反问题，实现了对粘弹性本构参数及第三类边界条件相关参数的多宗量组合识别。通过算例对所提方法的有效性进行了验证，考虑了区域非均质、裂纹、迭代初值、测量点位置/数量、及噪声等的影响，得到了令人满意的结果。

M10：微分方程反问题与数据驱动方法

（报告摘要按照姓氏拼音排序）

基于随机梯度重构的地震波成像方法

柴利慧

中山大学

Abstract: Seismic tomography solves high-dimensional optimization problems to image subsurface structures of Earth. In this work, we propose to use random batch methods to construct the gradient used for iterations in seismic tomography. Specifically, we use the frozen Gaussian approximation to compute seismic wave propagation, and then construct stochastic gradients by random batch methods. The method inherits the spirit of stochastic gradient descent methods for solving high-dimensional optimization problems. The proposed idea is general in the sense that it does not rely on the usage of the frozen Gaussian approximation, and one can replace it with any other efficient wave propagation solvers, e.g., Gaussian beam methods and spectral element methods. We prove the convergence of the random batch method in the mean-square sense, and show the numerical performance of the proposed method by two-dimensional and three-dimensional examples of wave-equation-based travel-time inversion and full-waveform inversion, respectively. As a byproduct, we also prove the convergence of the accelerated full-waveform inversion using dynamic mini-batches and spectral element methods. This is a joint work with Prof. Zhongyi Huang, Prof. Xu Yang, and Dr. Yixiao Hu.

Uniformly convex neural networks and non-stationary iterated network Tikhonov (iNETT) method

Davide Bianchi

哈尔滨工业大学（深圳）

Abstract: We propose a non-stationary iterated network Tikhonov (iNETT) method for the solution of ill-posed inverse problems. The iNETT employs deep neural networks to build a data-driven regularizer, and it avoids the difficult task of estimating the optimal regularization parameter. To achieve the theoretical convergence of iNETT, we introduce uniformly convex neural networks to build the data-driven regularizer. Rigorous theories and detailed algorithms are proposed for the construction of convex and uniformly convex neural networks. In particular, given a general neural network architecture, we prescribe sufficient conditions to achieve a trained neural network which is component-wise convex or uniformly convex; moreover, we provide concrete examples of realizing convexity and uniform convexity in the modern U-net architecture. With the tools of convex and uniformly convex neural networks, the iNETT algorithm is developed and a rigorous convergence analysis is provided. Lastly, we show applications of the iNETT algorithm in 2D computerized tomography, where numerical examples illustrate the efficacy of the proposed algorithm. Joint work with Wenbin Li and Guanghao Lai

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Identifiability of PDEs from Trajectory Data and Some Novel Methods based on Group Projected Subspace Pursuit

何雨晨

上海交通大学

Abstract: Thanks to the advanced data acquisition techniques, data-driven PDE identification has become a popular topic in various areas of science and industry. One can regard a wide class of PDEs as polynomials of partial derivatives of the functions of interest, and the unknown PDE is identified if the involved monomials are determined. This point of view fosters applications and developments of sparse-regression algorithms as well as model selection techniques. In the first part of the talk, we will introduce some recently proposed methods for PDE identification based on a newly developed group projected subspace pursuit algorithm. In the second part of the talk, we will provide some theoretical insights on the identifiability problem related to different types of PDEs. Specifically, we will consider when PDE can be exactly recovered and why certain types of PDEs are harder to identify than the others.

3D frequency-domain elastic wave modeling with spectral element methods using direct solvers

李扬

哈尔滨工业大学

Abstract: Complex topography, free surface boundary condition and inelastic properties of media should be well considered for onshore geophysical prospecting. Thus an appropriate and accurate forward modeling engine is very important. Unlike the time-domain implementation of many seismic imaging techniques, the counterpart in the frequency domain is rarely studied, in spite of having many advantages, for example, only limited number of frequencies is needed for the inversion process and solving the multiple-source problem is quite cheap if a direct solver is used. In this study, the spectral element method is applied to discretize the 3D frequency-domain anisotropic elastic wave modeling and parallel direct solvers (MUMPS and WSMP) are used to solve the generated linear system. The structure and the building process of the impedance matrix is thoroughly explained. We validate the numerical results by comparing with analytical solutions. Several tests are conducted to analyze the performance of solvers, e.g., the flops and memory cost during the factorization for different scale modeling. The influence of complex topography on MUMPS performance is also investigated. The statistics of the largest scale modeling feasible with current resources are summarized.

Theories for Learning Functions and Operators with Low-Dimensional Structures by Deep Neural Networks

刘皓

香港浸会大学

Abstract: Deep neural networks have demonstrated a great success on many applications, especially on problems with high-dimensional data sets. In spite of that, most existing theories are cursed by data dimension and cannot explain such a success. To bridge the gap between theories and practice, we exploit the low-dimensional structures of data set and establish theoretical guarantees with a fast rate that is only cursed by the intrinsic dimension of the data set. This presentation addresses our recent work on function approximation and operator learning by deep neural networks. The first part function approximation on low-dimensional manifolds. For Sobolev functions defined on a low-dimensional manifold, we show that neural networks can approximate both the function value and its gradient well. The network size critically depends on the intrinsic dimension of the manifold and only weakly depends on the ambient dimension. In the second part, we consider a general encoder-decoder framework to learn Lipschitz operators between infinite dimensional spaces by feedforward neural networks. Such a framework covers most scenarios in real applications. We develop non-asymptotic upper bounds for the generalization error of the empirical risk minimizer. When the problem have low-dimensional structures, our error bounds have a fast rate depending on the intrinsic dimension. Our results show that neural networks are adaptive to the low-dimensional structures of the problem.

Stochastic Asymptotical Regularization Stochastic asymptotical regularization for nonlinear ill-posed problems

龙海娥

深圳北理莫斯科大学

Abstract: We establish an initial theory regarding the stochastic asymptotical regularization (SAR) for the uncertainty quantification of the stable approximate solution of ill-posed nonlinear-operator equations, which are deterministic models for numerous inverse problems in science and engineering. By combining techniques from classical regularization theory and stochastic analysis, we prove the regularizing properties of SAR with regard to mean-square convergence. The convergence rate results under the canonical sourcewise condition are also studied. Several numerical examples are used to show the accuracy and advantages of SAR: compared with the conventional deterministic regularization approaches for deterministic inverse problems, SAR can provide the uncertainty quantification of a solution and escape local minimums for nonlinear problems.

Orientation estimation of cryo-EM images using projected gradient descent method

潘欢

深圳大学

Abstract: Orientation estimation is an important task in three-dimensional cryo-EM image reconstruction. By applying the common line method, the orientation estimation task can be formulated as a least squares (LS) problem or a least unsquared deviation (LUD) problem with orthogonality constraint. However, the non-convexity of the orthogonality constraint introduces numerical difficulties to the orientation estimation. The conventional approach is to reformulate the orthogonality constrained minimization problem into a semi-definite programming problem using convex relaxation strategies. In this paper, we consider a direct way to solve the constrained minimization problem without relaxation. We focus on the weighted LS problem because the LUD problem can be reformulated into a sequence of weighted LS problems using the iteratively reweighted LS approach. As a classical approach, the projected gradient descent (PGD) method has been successfully applied to solve the convex constrained minimization problem. We apply the PGD method to the minimization problem with orthogonality constraint and show that the constraint set is a generalized prox-regular set, and it satisfies the norm compatibility condition. We also demonstrate that the objective function of the minimization problem satisfies the restricted strong convexity and the restricted strong smoothness over a constraint set. Therefore, the sequence generated by the PGD method converges when the initial conditions are satisfied. Experimental results show that the PGD method significantly outperforms the semi-definite relaxation methods from a computation standpoint, and the mean square error is almost the same or smaller.

利用深度学习求解欠扩散问题中的正反问题

燕雄斌

上海交通大学

Abstract:在本报告中，我将汇报我们在利用深度学习求解欠扩散方程中正反问题的一些探索。内容包括：（1）利用神经网络学习欠扩散中的正演映射，并利用学好的算子神经网络加速求解欠扩散问题中的反演分数阶阶数和扩散系数问题；（2）我们探索利用 PINNs 方法求解欠扩散方程中的正反问题，针对自动微分无法得到分数阶导数的问题，我们提出 Laplace-fPINNs 方法。数值实验论证了我们提供的方法的有效性。

Hybrid Neural-Network FEM Approximation of Diffusion Coefficient in Elliptic and Parabolic Problems

周知

香港理工大学

Abstract: We investigate the numerical identification of the diffusion coefficient in elliptic and parabolic problems using neural networks. The numerical scheme is based on the standard output least-squares formulation where the Galerkin finite element method (FEM) is employed to approximate the state and neural networks (NNs) act as a smoothness prior to approximate the unknown diffusion coefficient. A projection operation is applied to the NN approximation in order to preserve the physical box constraint on the unknown coefficient. The hybrid approach enjoys both rigorous mathematical foundation of the FEM and inductive bias / approximation properties of NNs. We derive a priori error estimates in the standard L^2 norm for the numerical reconstruction, under a positivity condition which can be verified for a large class of problem data. The error bounds depend explicitly on the noise level, regularization parameter and discretization parameters (e.g., spatial mesh size, time step size, and depth, upper bound and number of nonzero parameters of NNs).

M11：数学图像处理和反问题

（报告摘要按照姓氏拼音排序）

A content-adaptive unstructured grid based regularized CT reconstruction method with a SART-type preconditioned fixed-point proximity algorithm

陈云

湘潭大学

Abstract: The goal of this study is to develop a new computed tomography (CT) image reconstruction method, aiming at improving the quality of the reconstructed images of existing methods while reducing computational costs. Existing CT reconstruction is modeled by pixel-based piecewise constant approximations of the integral equation that describes the CT projection data acquisition process. Using these approximations imposes a bottleneck model error and results in a discrete system of a large size. We propose to develop a content-adaptive unstructured grid (CAUG) based regularized CT reconstruction method to address these issues. Specifically, we design a CAUG of the image domain to sparsely represent the underlying image, and introduce a CAUG-based piecewise linear approximation of the integral equation by employing a collocation method. We further apply a regularization defined on the CAUG for the resulting ill-posed linear system, which may lead to a sparse linear representation for the underlying solution. The regularized CT reconstruction is formulated as a convex optimization problem, whose objective function consists of a weighted least square norm based fidelity term, a regularization term and a constraint term. Here, the corresponding weighted matrix is derived from the simultaneous algebraic reconstruction technique (SART). We then develop a SART-type preconditioned fixed-point proximity algorithm to solve the optimization problem. Convergence analysis is provided for the resulting iterative algorithm. Numerical experiments demonstrate the superiority of the proposed method over several existing methods in terms of both suppressing noise and reducing computational costs. These methods include the SART without regularization and with the quadratic regularization, the traditional total variation (TV) regularized reconstruction method and the TV superiorized conjugate gradient method on the pixel grid.

快速磁共振成像：深度迭代正则化方法论

崔卓须

中国科学院深圳先进技术研究院

Abstract: 快速磁共振成像(MRI)可以在数学上可以建模为一个反问题，正则化是实现鲁棒稳定求解的重要手段。然而，传统基于正则化的磁共振成像方法加速倍率已经接近极限。近年来，深度学习方法受到了越来越多的关注，并被广泛认为是实现进一步加速成像的突破口。与变分正则化相比，深度神经网络的级联结构更接近于迭代正则化。受此启发，提出了系列结合磁共振成像物理的深度迭代正则化方法来求解高加速倍率成像反问题，包括即插即用模型、深度展开模型和扩散模型。此外，在一定温和条件下，从迭代正则化理论阐述了其鲁棒性和稳健性。最后，部分相关方法已经实现与联影、安康等高端医疗设备企业合作，包括如 3.5 分钟超高分辨血管壁成像、直肠动态成像和低场 MRI 跨场强重建等高级应用。

A Shortened Model for Logan Reference Plot Implemented via the Self-Supervised Neural Network for Parametric PET Imaging

丁乔乔

上海交通大学

Abstract: Dynamic PET imaging provides superior physiological information than conventional static PET imaging. However, the dynamic information is gained at the cost of a long scanning protocol; this limits the clinical application of dynamic PET imaging. We developed a modified Logan reference plot model to shorten the acquisition procedure in dynamic PET imaging by omitting the early-time information necessary for the conventional reference Logan model. We designed a self-supervised convolutional neural network to increase the noise performance of parametric imaging, with dynamic images of only a single subject for training. The proposed method was validated via simulated and real dynamic 18F-fallypride PET data. Results showed that it accurately estimated the distribution volume ratio (DVR) in dynamic PET with a shortened scanning protocol, e.g., 20 minutes, where the estimations were comparable with those obtained from a standard dynamic PET study of 120 minutes of acquisition. Since the proposed method uses data acquired in a short period of time upon the equilibrium, it has the potential to add clinical values by providing both DVR and Standard Uptake Value (SUV) simultaneously. It thus promotes clinical applications of dynamic PET studies when neuronal receptor functions are studied.

ORKA: A new model for tracking moving and deforming objects

Florian Bossmann（德）

哈尔滨工业大学

Abstract: Data processing has to deal with many practical difficulties. Data is often corrupted by artefacts or noise and acquiring data can be expensive and difficult. Thus, the given data is often incomplete and inaccurate. To overcome these problems, it is often assumed that the data is sparse or low-dimensional in some domain. When multiple measurements are taken, this sparsity appears in a structured manner, i.e., the pattern of measurements taken in close proximity to each other will be related. We propose a new algorithm that assumes the data only contains a few relevant objects, i.e., it is sparse in some object domain. Again, the sparsity in multiple measurements should be structured. In our case, this means that an object can only change slightly from one observation to the other. We developed an object model that allows a change in position (movement of the object) and form (deformation, rotation, etc.). The change can be controlled to fit the physical constraints implied by the application. In this talk, we present the ORKA algorithm –Object reconstruction using K-approximation. This algorithm solves the object reconstruction problem with the above described model. The resulting problem is a mixed-integer programming problem. Using a separation of variables, we can divide it into a convex optimization problem and an integer problem. The latter one is then solved constructing a K-approximation graph. We can give theoretical error bounds of the algorithm and show its performance on applications such as video processing and geophysical exploration.

Template-based CT reconstruction with optimal transport and total generalized variation

高益铭

南京航空航天大学

Abstract: X-ray computed tomography (CT) has been widely used in clinical diagnosis as a modality of medical imaging. To decrease the radiation dose patients suffering from, sparse-view CT has gained much attention in medical imaging field. In this paper, we propose to design a variational model based on dynamic optimal transportation and total generalized variation (TGV) for CT reconstruction problem. This is a joint task involving an inverse problem and a template registration. The final state image of the optimal transport problem is unknown that is need to be reconstructed in CT inversion, while the given initial state can be regarded as a template which provides some structural information for the final one. Moreover, the existence and stability of minimizers to our proposed model are given in continuous space. In discretization with the continuity equation, we utilize the well-known staggered grid in fluid mechanics and develop a first-order algorithm based on primal-dual method for numerically solving the proposed model. Finally, numerical experiments for sparse-view CT reconstruction are exhibited to show the performance of our proposed model in recovering images with high quality and structure preservation.

Implicit Surface Reconstruction through Meshless Methods

雷敏

太原理工大学

Abstract: In this talk, we propose several PDE models for 3D implicit surface reconstruction from a set of scattered cloud data. Those models include various second-order/fourth-order PDEs. Nowadays，meshless methods obtain more and more attention due to their simplicity as well as high efficiency. Meshless methods play important roles in the surface reconstruction field. The meshless Radial Basis function (RBF) as well as the method of fundamental solution (MFS) are introduced and applied in the 3D reconstruction procedures here. It has been shown that PDE models like modified Helmholtz or Laplace equations are able to repair the surfaces when a certain region of cloud data is missing. In those models, the selection of free parameters in PDEs is also studied for the optimal recovery of surfaces. Finally, plenty of numerical examples are presented to demonstrate the effectiveness of the proposed models.

Sparse approximation and data processing

李嘉

中山大学

Abstract: In scientific research, sparse approximation scheme has been widely applied to various data processing problems especially when the prior knowledge is highly insufficient. In this presentation, I will briefly present my previous work in utilizing sparse approximation and designing novel models for image restoration, CT imaging and geometry reconstructions. In particular, dictionary learning by regions, multidimensional scaling from KNN distance, CT imaging by constrained model, region fill inpainting would be discussed as latest results.

Convergence Rate Analysis for Fixed-Point Iterations of Generalized Averaged Nonexpansive Operators

林义尊

暨南大学

Abstract: We estimate convergence rates for fixed-point iterations of a class of nonlinear operators which are partially motivated by convex optimization problems. We introduce the notion of the generalized averaged nonexpansive (GAN) operator with a positive exponent, and provide convergence rate analysis of the fixed-point iteration of the GAN operator. The proposed generalized averaged nonexpansiveness is weaker than averaged nonexpansiveness while stronger than nonexpansiveness. We show that the fixed-point iteration of a GAN operator with a positive exponent converges to its fixed-point and estimate the local convergence rate (the convergence rate in terms of the distance between consecutive iterates) depending on the range of the exponent. We prove that the fixed-point iteration of a GAN operator with a positive exponent strictly smaller than 1 can achieve an exponential global convergence rate (the convergence rate in terms of the distance between an iterate and the solution). Furthermore, we establish the global convergence rate of the fixed-point iteration of a GAN operator, depending on both the exponent of generalized averaged nonexpansiveness and the exponent of the Hölder regularity, if the GAN operator is also Hölder regular. We then apply the established theory to three types of convex optimization problems that appear often in data science to design fixed-point iterative algorithms for solving these optimization problems and to analyze their convergence properties.

Variational Rician Noise Removal via Splitting on Spheres

刘志方

天津师范大学

Abstract: In this talk, I will present a novel variational method to restore magnitude images corrupted by Rician noises in magnetic resonance (MR) imaging, based on the link of the Gaussian noise removal of complex MR images and the Rician noise removal of magnitude MR images. The proposed model consists of a spherical constraint, two quadratic terms and a total variation regularizer, which is different from the existing variational methods starting from maximum a posterior of Rician distribution and involving the Bessel function. The spherical constraint represents the forward model of calculating the magnitude MR images from complex MR images degraded by Gaussian noises. One of the two quadratic terms reflects the statistics of the noises and the other corrects the signal-dependent bias in the restored images. I will also present an alternating direction method of multipliers for solving the model and briefly analyze its convergence. This is a joint work with Huibin Chang and Yuping Duan.

Superiorized iteration algorithm for XCT image reconstruction and segmentation simultaneously

罗守胜

浙江师范大学

Abstract: In this talk, we propose a segmentation model for x-ray computed tomography (CT) image reconstruction, which can be applied to traditional CT and dual energy CT image reconstruction problem. It is difficult to solve the model due the large scale of image system and the DECT nonlinear forward projection. In order to solve the model, a superiorized iteration algorithm is presented, which handles image segmentation and image reconstruction alternately. The two steps are combined by a superiorized perturbation step. The convergence of the iteration procedure is proved for traditional CT image reconstruction. Experiments on various data are performed. Comparisons with existing methods show that the proposed method is better quantitatively and visually.

基于最优传输的非刚性图像配准模型、理论和算法

聂梓伟

南京大学

Abstract: 非刚性图像配准是医学图像处理与分析领域的基本问题，其关键在于找到两幅待配准图像在空间位置上的几何对应关系。在本次报告中，我们首先介绍医学图像非刚性配准的一些经典模型，然后在最优传输理论框架下建立相应的非刚性图像配准模型，给出模型的一些理论分析结果和数值计算方法并展示最优传输配准模型的一些实际配准结果。

A novel tensor regularization of nuclear over Frobenius norms for low rank tensor recovery

王超

南方科技大学

Abstract: We consider low-rank tensor recovery problems that include low-rank tensor completion (LRTC) and tensor robust principal component analysis (TRPCA). Based on the tensor singular value decomposition (t-SVD), we propose the ratio of the tensor nuclear norm and the tensor Frobenius norm (TNF) as a novel nonconvex surrogate of tensor's tubal rank in LRTC and TRPCA. For both models, we adopt the alternating direction method of multipliers (ADMM) to find a low-rank solution with guaranteed subsequential convergence under some conditions. Extensive experiments demonstrate the superiority of our proposed models over state-of-the-art methods.

医学成像：模型驱动 VS 数据驱动

王冬

东南大学丘成桐中心

Abstract: 医学成像是一类重要的应用科学问题，在临床诊疗中有着广泛的应用。医学临床上常用的成像方式有计算机断层扫描（CT）、磁共振成像（MRI）、正电子发射成像（PET）等。在实际应用中，医学成像通常会遇到扫描时间长、辐射剂量大等问题，因此快速、低剂量、高精度成像是医学成像领域所关注的问题。从方法论的角度而言，医学成像可以分为基于模型的方法、基于数据的方法、基于数据和模型双驱动的方法。在这次报告中，我会简单回顾医学成像中的常用方法，并给出我们在快速动态 MR 成像、低剂量 PET 成像中的最新进展。

Learnable Mixture Distribution Prior for Image Denoising

王发强

北京师范大学

Abstract: Non-Gaussian residual error and noise are common in the real applications, and they can be effificiently removed by some nonquadratic fifidelity terms in the classic variational method. However, they have not been well integrated to the architectures design in the convolution neural networks (CNN) based image denoising method. In this paper, we propose a deep learning approach to handle non-Gaussian residual error. Our method is developed on the universal approximation property for the probability density functions of the non-Gaussian error/noise. By considering the duality of the maximum likelihood estimation for the non-Gaussian noise, an adaptive weighting strategy can be derived for image fifidelity. To get a good image prior, a learnable regularizer is adopted. Solving such a problem iteratively can be unrolled as a weighted residual CNN architecture. The main advantage of our method is that the weighted residual block can well handle the non-Gaussian residual, especially for the noise with non-uniformly spatial distribution. Numerical results show that it has better performance on non-Gaussian noise (e.g. Gaussian mixture, random-valued impulse noise) removal than the existing methods.

Image segmentation using Bayesian inference for convex variant Mumford-Shah variational model

文有为

云南师范大学

Abstract: The Mumford-Shah model is a classical segmentation model, but its objective function is non-convex. The smoothing and thresholding (SaT) approach is a convex variant of the Mumford-Shah model, which seeks a smoothed approximation solution of the Mumford-Shah model. The idea of SaT is to separate the segmentation into two stages: a convex energy function is first minimized to obtain a smoothed image and then a thresholding technique is applied to segment the smoothed image. The energy function consists of three weighted terms and the weights are called the regularization parameters. It is important to select the appropriate regularization parameters to obtain a good segmentation result. Traditionally, the regularization parameters are usually chosen by trial-and-error, which is a very time-consuming procedure and is not practical in real applications. In this paper, we apply Bayesian inference approach to infer the regularization parameters and estimate the smoothed image. We analyze the convex variant Mumford-Shah variational model from the statistical perspective and then construct a hierarchical Bayesian model. Mean field variational family is used to approximate the posterior distribution. The variational density of the smoothed image is assumed to have Gaussian density, and the hyperparameters are assumed to have the Gamma variational densities. All the parameters in the Gaussian density and Gamma densities are iteratively updated, hence the proposed method is parameter-free. Experimental results show that the proposed approach can obtain good segmentation results. Although the proposed approach contains an inference step to estimate the regularization parameters, it requires less CPU running times to obtain the smoothed image comparing to previous methods."

Multiplicative noise removal and contrast enhancement for SAR images based on a total fractional-order variation model

姚文娟

哈尔滨工业大学

Abstract: In this talk, I will introduce a total fractional-order variation model for multiplicative noise removal and contrast enhancement in real SAR images. Inspired by the high dynamic intensity range of SAR images, the proposed model first preserves the full content of the SAR images by normalizing the original data. Then, we propose a degradation model based on the modified noise pattern by using nonlinear transformation to adjust the intensity of image pixel values. With the new degraded model, a corresponding fidelity term is introduced to the proposed total fractional-order variation model, which is benefit to enhance the contrast of image textures and the bias correction. For the regularization term, a gray level indicator is introduced into the proposed model to make it adaptive. We apply the scalar auxiliary variable algorithm to solve the proposed model and prove the convergence of the algorithm. By virtue of the discrete Fourier transform (DFT), the model is solved by an iterative scheme in the frequency domain. Experimental results show that the proposed model can remove multiplicative noise and enhance the contrast both in natural images and SAR images.

Variational image-based Rapidly-exploring Random Tree and its applications

张建峰

浙江师范大学

Abstract: We proposed a Rapidly exploring Random Tree method based on image pixel/voxel and its variational optimization models. Thereinto, we design ed a unique cost metric function, a sampling operator and so on, to realize the continuous computation of the classical incremental search framework in image space. In this talk, we will present some application cases of the variational image based Rapidly exploring Random Tree method in natural and medical images, especially the computation and simulation of the growth and bifurcation of hepatic vasculature under the guidance of Murray's law.

Variational Image Registration Model with Diffeomorphism Constraints and Its Implementation

张建平

湘潭大学

Abstract: Image registration has played an important role in image processing problems, especially in medical imaging applications. It is well known that when the deformation is large, many variational models cannot ensure diffeomorphism. In this paper, we propose a new registration model based on an optimal control relaxation constraint for large deformation images, which can theoretically guarantee that the registration mapping is diffeomorphic. We present an analysis of optimal control relaxation for indirectly seeking the diffeomorphic transformation of the Jacobian determinant equation and its registration applications. We also provide an existence result for the control increment optimization problem in the proposed diffeomorphic image registration model. Furthermore, a fast iterative scheme based on the augmented Lagrangian multipliers method (ALMM) is analyzed to solve the control increment optimization problem, and a convergence analysis follows. Numerical experiments show that the registration model we propose not only obtains a diffeomorphic mapping when the deformation is large but also achieves a state-of-the-art performance in quantitative evaluations that is comparable to that of other classical models.

Optimal Transport for Positive and Unlabeled Learning And Its Application in Windshear Detection

张婕

香港大学

Abstract: Positive and unlabeled learning (PUL) aims to train a binary classifier based on labeled positive and unlabeled samples, which is challenging due to the unavailability of negative training samples. This talk will introduce a novel optimal transport model with a regularized marginal distribution for PUL. By using the Frank-Wolfe algorithm, one can properly solve the proposed model. Extensive experiments on simulated and real-world data sets showed the proposed method is effective. Moreover, combined with a multi-instance learning scheme, we applied it to wind shear detection at Hong Kong International Airport (HKIA) and achieved a pretty good performance.

面向区域的小样本图像分割

张立

北京大学

Abstract: As one of the most challenging and practical segmentation tasks in real-world, Open-world semantic segmentation requires the model to segment the anomaly regions in the images and then incrementally learn to segment out-of-distribution (OOD) objects, especially under a few-shot condition. The current state-of-the-art (SOTA) methods rely on pixel-level metric learning, with which the identification of similar regions having different semantics is difficult. Therefore, we propose a method based on region-aware approaches, which separates the regions of the images and generates region-aware features for further deep learning. Our approach improves the integrity of the segmented anomaly regions. Moreover, we propose novel region separation modules to further identify anomaly regions, forming high-quality sub-region candidates and thereby improving the model performance for OOD objects.

M12：反散射问题的分析与计算

（报告摘要按照姓氏拼音排序）

Inverse wave-number-dependent source problems for the Helmholtz equation with multi-frequency factorization method

郭红霞

南开大学

Abstract: In this talk, we concern the multi-frequency factorization method for imaging the support of a wave-number-dependent source function. It is supposed that the source function is given by the Fourier transform of some time-dependent source with a priori given radiating period. Using the multi-frequency far-field data at a fixed observation direction, we provide a necessary and sufficient criterion for characterizing the smallest strip containing the support and perpendicular to the observation direction. The far-field data for sparse observation directions can be used to recover a Θ-convex polygon of the support. Uniqueness in recovering the convex hull of the support is obtained as a by-product of the reconstruction method with the data of all observation directions. The reconstruction method is proven valid even with multi-frequency near-field data and its connections to time-dependent inverse source problems are discussed. We also comment on possible extensions to source functions with two disconnected supports. Numerical tests are implemented to show effectiveness and feasibility of the approach. The proposed scheme can also be regarded a frequency method for recovering the support of a time-dependent source fulfilling a coercivity condition.

Increasing stability for inverse acoustic source problems in the time domain

刘春

南开大学

Abstract: This talk is concerned with the increasing stability of the inverse source problem for the wave equation from boundary Dirichlet data in the full space. When source term has special form and compact supports, the increasing stability estimates are obtained. Our results show that increasing stability estimates of the L2 -norm of the acoustic source function can be established by using only the Dirichlet boundary data. This is a joint work with Prof. Bo Zhang and Guanghui Hu.

Determination of some new eigenvalues from scattered field

刘娟

暨南大学

Abstract: Recently, the modified transmission eigenvalue and Stekloff eigenvalue problems were introduced and used as a target signature for nondestructive testing. This talk will consider the inverse spectral problem to reconstruct the Stekloff and modified transmission eigenvalues using Cauchy data. We propose a reciprocity gap functional method and show that the eigenvalues can be determined by solving some linear ill-posed integral equations. Numerical examples for both absorbing and non-absorbing media are presented to validate the effectiveness and robustness of the proposed method.

Imaging a moving point source from multi-frequency data measured at one and sparse observation directions (part I): far-field case

马冠球

南开大学

Abstract: We propose a multi-frequency algorithm for recovering partial information on the trajectory of a moving point source from one and sparse far-field observation directions in the frequency domain. The starting and terminal time points of the moving source are both supposed to be known. We introduce the concept of observable directions (angles) in the far-field region and derive all observable directions (angles) for straight and circular motions. The existence of non-observable directions makes this paper much different from inverse stationary source problems. At an observable direction, it is verified that the smallest trip containing the trajectory and perpendicular to the direction can be imaged, provided the angle between the observation direction and the velocity vector of the moving source lies in $[0,\pi/2]$.If otherwise, one can only expect to recover a strip thinner than this smallest strip for straight and circular motions.The far-field data measured at sparse observable directions can be used to recover the Θ-convex domain of the trajectory. Both two- and three-dimensional numerical examples are implemented to show effectiveness and feasibility of the approach.

Fourier-Galerkin method for the transmission eigenvalue problem based on a boundary integral formulation

马云云

东莞理工学院

Abstract: This talk is concerned with the numerical computation of transmission eigenvalues in the inverse scattering theory, which are shed light on the material properties of scattering object. The problem is formulated as the eigenvalue problem of a holomorphic Fredholm operator function based on boundary integral operators. The approximation properties of the associated discrete operators are analyzed and some convergence results of eigenvalues are obtained. Numerical examples validate the effectiveness and accuracy of that method.

Increasing stability for the inverse source problems in elastodynamics

司苏亮

山东理工大学

Abstract: We are concerned with increasing stability of the inverse source problem for the elastic wave equation from boundary Dirichlet data in the full space R^3 . When source term has special form and compact supports, the increasing stability estimates are obtained. Our results show for the first time that increasing stability estimates of the L^2 -norm of source
function can be established by using only the Dirichlet boundary data. The main goal of this talk is to understand increasing stability for the elastic wave equation in the time domain.

Reconstruction of acoustic sources from multi-frequency phaseless far-field data

孙凤麟

天津师范大学

Abstract: This talk concerns the application of adding reference point sources to the scattering system in solving inverse problems, mainly focusing on the problem of determining an acoustic source from multi-frequency phaseless far-field data. By supplementing two reference sources in the inverse source model, we developed a novel strategy to recovering the phase information of far-field data. This reference source technique leads to an easy-to-implement phase retrieval formula. Mathematically, the stability of the phase retrieval approach is rigorously justified. Then we employ the Fourier method to deal with the multi-frequency inverse source problem with recovered phase information. This method is fast and easy to implement, as only cheap integration is involved in the evaluation of Fourier coefficients. This talk is based on a joint work with Wang Xianchao.

Uniqueness in determining rectangular grating profiles with a single incoming wave: TM polarization case

向建立

三峡大学

Abstract: We consider an inverse transmission problem for recovering the shape of a penetrable rectangular grating sitting on a perfectly conducting plate. In the TM polarization case, it is proved that a rectangular grating profile can be uniquely determined by the near-field observation data incited by a single plane wave and measured on a line segment above the grating. In comparision with the TE case, the wave field cannot lie in H^2 around each corner point, bringing essential difficulties in proving uniqueness with one plane wave. Our approach relies on singularity analysis for Helmholtz transmission problems in a right-corner domain and also provides an alternative idea for treating the TE transmission conditions which were considered in the authors' previous work [Inverse Problem, 39 (2023): 055004].

Direct sampling method to inverse wave-number-dependent source problems (part I): determination of the support of a stationary source

赵孟洁

南开大学

Abstract: This paper is concerned with a direct sampling method for imaging the support of a frequency-dependent source term embedded in a homogeneous and isotropic medium. The source term is given by the Fourier transform of a time-dependent source whose radiating period in the time domain is known. The time-dependent source is supposed to be stationary in the sense that its compact support does not vary along the time variable. Via a multi-frequency direct sampling method, we show that the smallest strip containing the source support and perpendicular to the observation direction can be recovered from far-field patterns at a fixed observation angle. With multiple but sparse observation directions, the shape of the so-called Θ-convex hull of the source support can be recovered. The frequency-domain analysis performed here can be used to handle inverse time-dependent source problems. Our algorithm has low computational overhead and is robust against noise. Numerical experiments in both two and three dimensions have proved our theoretical findings.

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Reconstruction of Multiscale Electromagnetic Sources from Multi-frequency Electric Far Field Patterns at Sparse Observation Directions

李佳磊

中科院数学院应用数学所

Abstract: We introduce a multi-step scheme for reconstructing multiscale sources from multifrequency sparse electric far field patterns. The unknown source is a combination of electric dipoles, magnetic dipoles and extended sources. The dipoles are shown to be uniquely identified by the multi-frequency electric far field patterns at properly chosen sparse observation directions. Numerical algorithms are introduced to reconstruct the multiscale source. The stability of the formulas with respect to the frequency band is also derived. The efficiency of the proposed algorithms is verified by numerical examples.

Two-layer networks with the ReLU^k activation function: Barron spaces and derivative approximation

李圆媛

复旦大学

Abstract: We investigate the use of two-layer networks with the rectified power unit, which is called the ReLU^k activation function, for function and derivative approximation. By extending and calibrating the corresponding Barron space, we show that two-layer networks with the ReLU^k activation function are well-designed to simultaneously approximate an unknown function and its derivatives. When the measurement is noisy, we propose a Tikhonov type regularization method, and provide error bounds when the regularization parameter is chosen appropriately. Several numerical examples support the efficiency of the proposed approach.

A mixed element scheme for the Helmholtz transmission eigenvalue problem for anisotropic media

刘庆

东南大学

Abstract: In this paper, we study the Helmholtz transmission eigenvalue problem for inhomogeneous anisotropic media with the index of refraction $n(x)\equiv 1$ in two and three dimensions. Starting with the nonlinear fourth-order formulation established by Cakoni, Colton and Haddar[4], we present an equivalent mixed formulation for this problem with auxiliary variables, followed by finite element discretization. Using the proposed scheme, we rigorously show that the optimal convergence rate for the transmission eigenvalues on both convex and nonconvex domains can be expected. With this scheme, we obtain a sparse generalized eigenvalue problem whose size is too demanding, even with a coarse mesh that its smallest few real eigenvalues fail to be solved by the shift and invert method. We partially overcome this critical issue by deflating nearly all of the ∞ eigenvalues with huge multiplicity, resulting in a marked reduction in the matrix size without deteriorating the sparsity. Extensive numerical examples are reported to demonstrate the effectiveness and efficiency of the proposed scheme.

Identification of acoustic point sources in a two-layered medium from multi-frequency sparse far field patterns

史庆祥

中科院数学院应用数学所

Abstract: We consider the reconstruction of point sources in a two layered medium from the multi-frequency sparse far field patterns taken on the upper half sphere. The point sources are located in both the upper half space and the lower half space. After establishing the uniqueness of the point sources by the multi-frequency far field patterns at properly chosen sparse observation directions, we introduce a multi-step numerical scheme for identifying all the points sources. Numerical examples show that the proposed sampling methods work very well for locating the positions and the formulas for determining the corresponding scattering strengths are valid and stable with respect to the noises.

心电图成像的等效模型与时空联合的反演算法

王丽艳

东南大学

Abstract: 心电图成像(electrocardiogram imaging，ECGI)技术通过对患者三维心脏进行数字化建模，能够直接且非侵入性地重建刻画心电活动中的关键特征,进而有望起到个性化诊断和辅助治疗的功能，日益得到医学诊疗前沿领域的广泛关注。等效模型的基本原理是由体表电位反演心脏表面等效电位，再根据其随时间变化的特征对心脏除极复极等电活动进行图像化的展现。由于反问题本身的不适定性和技术应用的综合性特点，需要科学、工程及医学等跨领域间的持续协作研究，以达到预期的临床应用要求。本报告将从数学建模的角度，介绍心电图成像中涉及的偏微分方程反问题模型和相应数值算法，进一步探讨可能的理论发展及应用方向。

Traceability of Water Pollution: Dynamic CGO Solutions for Inverse Source Problem and Its Application

于沈文

清华大学

Abstract: We aim to find the time-dependent source term in the diffusion equation from the boundary measurement, which allows for the possibility of tracing back the source of pollutants in the environment. Based on the idea of dynamic complex geometrical optics (CGO) solutions, we analyze a variational formulation of the inverse source problem and prove the uniqueness result. A two-step reconstruction algorithm is proposed, which first recovers the locations of the point sources, and then the Fourier components of the emission concentration functions are reconstructed. Numerical experiments on simulated data are conducted. The results demonstrate that our proposed two-step reconstruction algorithm can reliably reconstruct multiple point sources and accurately reconstruct the emission concentration functions. In addition, we decompose the algorithm into two parts: online and offline computation, with most of the work done offline. This paves the way toward real-time traceability of the pollution. The proposed method can be used in many fields, particularly those related to water pollution, to identify the source of a contaminant in the environment and can be a valuable tool in protecting the environment.

WANCO: Weak Adversarial Network for Constrained Optimization problems

邹柏毅

香港中文大学（深圳）

Abstract: This paper focuses on integrating adversarial thinking into constrained optimization problems, particularly within the framework of Partial Differential Equations (PDEs). For PDE problems with constraints, we first transform them into a minimax problem using the Augmented Lagrangian method. Then, we use two Deep Neural Networks (DNNs) to represent the primal and adversarial variables, respectively, and solve this saddle-point problem by updating the parameters of the two neural networks to obtain a solution to the original problem. The proposed algorithm is less sensitive to the parameter settings of the loss function, and it is a framework-based approach that can handle various types of constraint problems, such as scalar constraints, PDE constraints, and inequality constraints. In the numerical experiment section, we demonstrate the effectiveness and robustness of the proposed method on different constrained optimization problems, including Ginzburg-Landau energy problems, Dirichlet partition problems, topology optimization problems, and obstacle problems.

A linearization approach to inverse Schr\"odinger potential problem with power type nonlinearities

邹森

复旦大学

Abstract: In this talk, I will introduce the inverse problem about the recovery of the potential function from the nonlinear Schr\"odinger equation with power type nonlinearities. Based on a linearization approach, we propose a reconstruction scheme from the nonlinear measurements. The increasing stability for this linearization approach is proved and numerical experiments show its validity.
