

反问题理论与计算方法小型研讨会

周三 29.04.2026

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会议地点：光华东主楼 1601，复旦大学邯郸校区，杨浦区邯郸路 220 号



*上图中右边高楼为光华楼

摘要信息

Hybrid projection methods for solution decomposition in large-scale Bayesian inverse problems

姜嘉骅 (上海科技大学)

摘要: We develop hybrid projection methods for computing solutions to large-scale inverse problems, where the solution represents a sum of different stochastic components. Such scenarios arise in many imaging applications (e.g., anomaly detection in atmospheric emissions tomography) where the reconstructed solution can be represented as a combination of two or more components and each component contains different smoothness or stochastic properties. In a deterministic inversion or inverse modeling framework, these assumptions correspond to different regularization terms for each solution in the sum. Although various prior assumptions can be included in our framework, we focus on the scenario where the solution is a sum of a sparse solution and a smooth



solution. For computing solution estimates, we develop hybrid projection methods for solution decomposition that are based on a combined flexible and generalized Golub–Kahan process. This approach integrates techniques from the generalized Golub–Kahan bidiagonalization and the flexible Krylov methods. The benefits of the proposed methods are that the decomposition of the solution can be done iteratively, and the regularization terms and regularization parameters are adaptively chosen at each iteration. Numerical results from photoacoustic tomography and atmospheric inverse modeling demonstrate the potential for these methods to be used for anomaly detection.

Multi-contrast in vivo optical tomography

任无畏（上海科技大学）

摘要：Multi-contrast imaging technology is of great value in biomedical research and clinical diagnosis. Taking magnetic resonance imaging (MRI) as an example, the multi-contrast data generated by its multi-sequence scanning can meet the diverse clinical diagnostic needs through the complementary integration of structural and functional information. In the field of optical imaging, multi-contrast technology can not only enhance the data dimension, but also break through the bottleneck of quantification: for example, the deviation of optical absorption/scattering coefficients in fluorescence imaging will significantly affect the three-dimensional quantitative reconstruction of fluorescent probes, and the multi-contrast strategy of synchronously acquiring optical coefficients and fluorescence distribution can effectively solve this problem. This study integrates structured light illumination, single-photon avalanche diodes (SPADs) array detection and pulsed laser modulation to construct a multi-contrast optical tomography system (SHMOT). The system can simultaneously achieve high-precision reconstruction of tissue surface, three-dimensional analysis of optical absorption/scattering coefficients, and visualization of quantitative distribution of exogenous fluorescent probes. After the reliability of the system was verified by digital simulation and phantom experiments, SHMOT has been successfully applied to in vivo tumor microenvironment imaging and dynamic monitoring of thermal ablation temperature field in mice. This technology shows clear clinical application potential in fluorescence-guided surgical navigation and non-invasive brain-computer interfaces.

大气遥感中的反问题：面向对流层、电离层与 GNSS-R 海洋参数反演的建模与优化

吴志露 (同济大学)

摘要：本次汇报主要介绍汇报人在对流层、电离层和海洋遥感反演方面的一些工作，并尝试从反问题的角度对这些问题做统一理解。相关研究包括：基于 GNSS 和遥感卫星的对流层延迟和水汽反演、对流层场的超分辨率反演、电离层参数反演及海洋区域优化，以及 GNSS-R 海面波高等海洋要素反演。

这些问题虽然应用背景不同，但本质上都属于由有限观测反推复杂介质状态或参数的反问题，普遍存在非线性、病态性、多解性以及先验约束敏感等特点。我希望借此次交流，梳



理这些问题在前向建模、可辨识性分析、正则化构造和多源数据融合方面的共性，也进一步思考数学反问题理论在遥感和 GNSS 反演中的应用潜力。

面向复杂条件的卫星精密导航定位

章浙涛 (同济大学)

摘要：在卫星端、传播端和用户端的复杂条件下，容易受到观测数据质量下降、数学模型解算异常、定位性能频繁恶化等影响，用户难以实现高精度高可信定位、导航和授时服务。针对上述问题，首先系统探讨了非模型化误差实时处理以及整周模糊度快速解算的理论与方法，接着给出了几种适用于复杂条件的卫星导航定位新技术。要实现复杂条件下卫星精密导航定位，本质上是需要解决高维有偏非线性混合整数优化的数学问题。目前，传统处理方法虽然有效，但在一些复杂条件下仍有其局限性。另一方面，随着人工智能尤其是深度学习等技术的出现，如何更好地将其应用于卫星精密导航定位领域，仍有许多问题需要探讨和解决。本报告就以上问题开展交流和探讨。

