2022

7月16-17日

张量优化与应用研讨会

北京交通大学

2022 年张量优化与应用研讨会

（2022 年 7 月 16 日-17 日，北京）

一、会议宗旨

　　张量优化是大数据与人工智能时代高维复杂数据处理中孕育出来的一类新兴的优化分支，是张量分析、最优化、数据科学等学科交叉融合的产物。为促进张量优化的发展，增进本领域及相关领域专家学者之间的交流，中国运筹学会数学规划分会和北京交通大学数学与统计学院将于 2022 年 7 月 16 日至 17 日线上举办 2022 年张量优化与应用研讨会。

二、会议主题

　　张量优化前沿理论与算法及其应用，内容包括但不限于：张量分析与张量优化、张量互补与变分不等式、张量计算及其在统计学、机器学习、图像与信号处理等领域的应用。

三、学术委员会

主　任：戴彧虹　　（中科院数学与系统科学研究院）

　　　　修乃华　　（北京交通大学）

委　员：徐大川　　（北京工业大学）

　　　　凌晨　　　（杭州电子科技大学）

　　　　黄正海　　（天津大学）

　　　　魏益民　　（复旦大学）

　　　　李董辉　　（华南师范大学）

　　　　杨庆之　　（南开大学）

四、组织委员会

主　任：罗自炎　　（北京交通大学）

委　员：牛璐　　　（北京交通大学）

　　　　张立平　　（清华大学）

　　　　崔春风　　（北京航空航天大学）

　　　　孔令臣　　（北京交通大学）

　　　　张超　　　（北京交通大学）

五、邀请报告专家（按照姓氏汉语拼音排序）

　　　　白敏茹　　（湖南大学）

　　　　黎稳　　　（华南师范大学）

林华珍 （西南财经大学）

林宙辰 （北京大学）

罗珊 （上海交通大学）

倪谷炎 （国防科技大学）

聂家旺 （加州大学圣地亚哥分校）

祁力群 （杭州电子科技大学）

吴国宝 （香港大学）

严洪 （香港城市大学）

赵俊龙 （北京师范大学）

六、会议信息与联系方式

在线会议信息：腾讯会议 ID：784-3926-6752　密码：1234

会议微信群二维码：

会议联系方式：

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中国运筹学会数学规划分会

北京交通大学数学与统计学院

会议日程

|	时间	报告人	题目	主持人
7 月 16 日	8:30-9:00		开幕式致辞 北京交通大学数学与统计学院院长　于永光 中国运筹学会理事长　戴彧虹	罗自炎
	9:00-10:00	祁力群	Standard Dual Quaternion Optimization and Its Application in the Hand-Eye Calibration Problem	凌晨
	10:00-11:00	吴国宝	Optimization and Applications in Hyperspectral Image Processing	常安
	11:00-12:00	严洪	Tensor Models for Image and Video Analysis	
	12:00-14:00		午餐	
	14:00-15:00	罗珊	A Portmanteau Local Feature Discrimination Approach to the Classification with High-dimensional Matrix-variate Data	魏益民
	15:00-16:00	林华珍	Generalized Factor Model for Ultra-high Dimensional Correlated Variables with Mixed Types	
	16:00-16:20		茶歇	
	16:20-17:20	林宙辰	Tensor Q-Rank: New Data Dependent Definition of Tensor Rank	王卿文
	17:20-18:20	黎稳	Multi-linear PageRank：Uniqueness and Algorithms	
	18:20		晚餐	
7 月 17 日	8:30-9:30	聂家旺	Learning Diagonal Gaussian Mixture Models and Incomplete Tensor Decompositions	杨庆之
	9:30-10:30	赵俊龙	Dimension Reduction for Covariates in Network Data	
	10:30-11:30	白敏茹	Robust Tensor Completion: Equivalent Surrogates, Error Bounds and Algorithms	范金燕
	11:30-12:30	倪谷炎	Rank-R Positive Hermitian Approximation Algorithms and Positive Hermitian Decompositions of Hermitian Tensors	
	12:30-12:50		闭幕式 中国运筹学会数学规划分会理事长　徐大川	孔令臣

Standard Dual Quaternion Optimization and Its Application in the Hand-Eye Calibration Problem

祁力群 教授

杭州电子科技大学

摘 要：The dual quaternion optimization problem, where objective and constraint functions have dual quaternion variables and dual number function values naturally arises from applications. In this paper, we show that several common dual quaternion functions, such as the power function, the magnitude function, the 2-norm function and the kth largest eigenvalue function of dual quaternion Hermitian matrices, are standard dual quaternion functions, i.e., the standard parts of their function values depend upon only the standard parts of the dual quaternion variables. Furthermore, the sum, product, minimum, maximum and composite functions of two standard dual functions, the logarithm and the exponential of a standard unit dual quaternion functions, are still standard dual quaternion functions. We show that to solve an equality constrained standard dual quaternion optimization problem, we only need to solve two quaternion optimization problems. We briefly discussed the solution method for the general standard dual quaternion optimization problem. Thus, if the dual quaternion functions are standard, the related dual quaternion optimization problem is solvable. Then, we show that the dual quaternion optimization problems arising from the hand-eye calibration problem are equality constrained standard dual quaternion optimization problems.
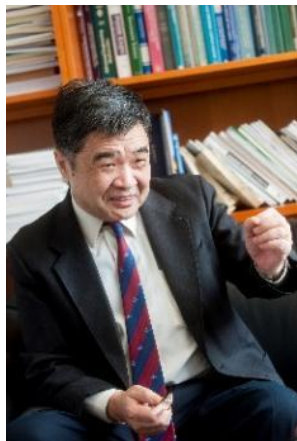
报告人简介：祁力群，1968 年本科毕业于清华大学，1981 年和 1984 年在美国威斯康星大学麦迪逊分校分别取得硕士和博士学位。曾任教于清华大学、澳大利亚新南威尔士大学、香港城市大学和香港理工大学，现为香港理工大学应用数学荣休教授，杭州电子科技大学特聘教授。他建立了半光滑牛顿方法的超线性收敛理论，以及光滑化牛顿方法的全局收敛理论，于 2010 年获得中国运筹学会科学技术一等奖。祁力群教授在国际杂志上发表论文 370 余篇，其成果在世界上被广泛应用，被列 2003-2010 年度世界高被引数学家，在 2018，2019 和 2020 被再次列为世界高被引数学家，入选 2021 年度"全球前 2%顶尖科学榜单"。祁教授在澳大利亚和香港高校工作期间都连年取得科研基金，自 1999 年底到香港以来，连续十八年取得香港科研基金，自 2007 年开始在香港基金会理科审评组工作。祁力群教授在十个国际杂志担任主编或编委，并在澳大利亚、中国大陆、意大利和香港组织多次国际学术会议。祁力群教授在 2005 年提出高阶张量特征值，继而形成高阶张量谱理论，在生物医学工程，超图谱理论和量子力学等方面取得应用，并于 2017 年和 2018 年分别在美国工业应用数学协会和斯普林格出版社出版张量理论的英文专著 2 部。

Optimization and Applications in Hyperspectral Image Processing

吴国宝　教授

香港大学

摘 要： In this talk, hyperspectral image processing methods, e.g., denoising, demosaicing, and destriping, etc are discussed and reported for tensor optimization and applications. Numerical examples are given to demonstrate the performance of such methods.

报告人简介： 吴国宝，数学家，美国工业与应用数学学会院士(SIAM Fellow)，第十二届冯康科学计算奖得主，现任香港大学数学系讲座教授。主要研究方向为应用与计算数学、 人工智能与机器学习、数据与影像科学与数值线性代数与科学计算。吴国宝教授先后担任多个著名杂志主编或者副主编，包括 SIAM Journal on Imaging Sciences, SIAM Journal on Scientific Computing, Journal of Scientific Computing, Journal of Computational and Applied Mathematics 等。吴国宝教授发表学术著作 700 多篇，文章引用次数达 2 万多次。

Tensor Models for Image and Video Analysis

严洪　教授

香港城市大学

摘要： Tensor models can be used for multidimensional data representation and analysis effectively. In this presentation, we discuss our recent work on solving several image and video recognition problems using higher-order tensors. A short video can be considered as a third-order tensor and incremental singular value decomposition (SVD) can be applied to the data. The decomposition is updated gradually rather than computed for each overlapping period independently, and this can reduce the computing time significantly and make it possible to implement object tracking in real-time. Each singular vector in SVD is derived from all the input data and the change of a single data entry can alter the decomposition results. We have recently studied CUR decomposition to overcome this limitation. Instead of combining the input data, we sample them in CUR decomposition. Only a small number of tensor fibers are needed to represent a low-rank tensor. We will report our recent work on image matching using CUR decomposition. Other related work, such as hardware accelerators for tensor computing will also be discussed.

报告人简介：严洪，耶鲁大学博士，现任香港城市大学教授，US National Academy of Inventors (NAI) Fellow, Institute of Electrical and Electronics Engineers (IEEE) Fellow, International Association for Pattern Recognition (IAPR) Fellow. 2016 年获 IEEE SMC Society 颁发的诺伯特·维纳奖(Norbert Wiener Award), 该奖项被视为 IEEE 控制学领域的最高荣誉。在学术期刊和会议上发表论文 600 余篇，主要研究方向为图像处理与计算机视觉，计算机动画，机器学习，计算生物学与医学等。

A Portmanteau Local Feature Discrimination Approach to the Classification with High-dimensional Matrix-variate Data

罗珊　教授

上海交通大学

摘要：Matrix-variate data arise in many scientific fields such as face recognition, medical imaging, etc. Matrix data contain important structure information which can be ruined by vectorization. Methods incorporating the structure information into analysis have significant advantages over vectorization approaches. In this article, we consider the problem of two-class classification with high-dimensional matrix-variate data, and propose a novel portmanteau-local-feature discrimination (PLFD) method. This method first identifies local discrimination features of the matrix variate and then pools them together to construct a discrimination rule. We investigated the theoretical properties of the PLFD method and established its asymptotic optimality. We carried out extensive numerical studies including simulation and real data analysis to compare this method with other methods available in the literature, which demonstrate that the PLFD method has a great advantage over the other methods in terms of misclassification rate.

报告人简介：罗珊，新加坡国立大学统计学博士，密歇根大学生物统计系访问学者。现为上海交通大学数学科学学院长聘副教授。主要研究领域为高维数据中的模型选择标准、变量选择方法和统计推断。文章主要发表在 Journal of the American Statistical Association，Statistica Sinica, Journal of Multivariate Analysis, Annals of the Institute of Statistical Mathematics, Computational Statistics and Data Analysis, Journal of Statistical Planning and Inference 等期刊上。

Generalized Factor Model for Ultra-high Dimensional Correlated Variables with Mixed Types

林华珍　教授

西南财经大学

摘 要：As high-dimensional data measured with mixed-type variables gradually become prevalent, it is particularly appealing to represent those mixed-type high-dimensional data using a much smaller set of so-called factors. Due to the limitation of the existing methods for factor analysis that deal with only continuous variables, in this paper, we develop a generalized factor model, a corresponding algorithm and theory for ultra-high dimensional mixed types of variables where both the sample size n and variable dimension p could diverge to infinity. Specifically, to solve the computational problem arising from the non-linearity and mixed types, we develop a two-step algorithm so that each update can be carried out in parallel across variables and samples by using an existing package. Theoretically, we establish the rate of convergence for the estimators of factors and loadings in the presence of nonlinear structure accompanied with mixed-type variables when both n and p diverge to infinity. Moreover, since the correct specification of the number of factors is crucial to both the theoretical and the empirical validity of factor models, we also develop a criterion based on a penalized loss to consistently estimate the number of factors under the framework of a generalized factor model. To demonstrate the advantages of the proposed method over the existing ones, we conducted extensive simulation studies and also applied it to the analysis of the NFBC1966 dataset and a cardiac arrhythmia dataset, resulting in more predictive and interpretable estimators for loadings and factors than the existing factor model.

报告人简介：林华珍，西南财经大学首席教授，统计研究中心主任。国际数理统计学会 IMS-fellow，教育部长江学者特聘教授，国家杰出青年科学基金获得者，国家百千万人才工程获得者，享受国务院政府特殊津贴专家。 主要研究方向为非参数方法、转换模型、生存数据分析、函数型数据分析、因子模型，研究成果发表在包括国际统计学四大顶级期刊 AoS, JASA, JRSSB, Biometrika 和计量经济学顶级期刊 JOE 及 JBES 上。林教授是国际 IMS-China, IBS-CHINA 及 ICSA-China 委员，中国现场统计研究会副理事长，中国现场统计研究会数据科学与人工智能分会理事长，第九届全国工业统计学教学研究会副会长，中国现场统计研究会多个分会的副理事长。先后是国际统计学期刊 Biometrics, Journal of Business & Economic Statistics, Scandinavian Journal of Statistics, Canadian Journal of Statistics, Statistics and Its Interface, Statistical Theory and Related Fields, Associate Editor，国内核心学术期刊《应用概率统计》、《系统科学与数学》、《数理统计与管理》编委。

Tensor Q-Rank: New Data Dependent Definition of Tensor Rank

林宙辰　教授

北京大学

摘要：Recently, the Tensor Nuclear Norm (TNN) regularization based on t-SVD has been widely used in various low tubal-rank tensor recovery tasks. However, these models usually require smooth change of data along the third dimension to ensure their low rank structures. In this talk, I will introduce a new definition of data dependent tensor rank named tensor Q-rank by a learnable orthogonal matrix Q, and further introduce a unified data dependent low rank tensor recovery model. According to the low rank hypothesis, we introduce two explainable selection method of Q, under which the data tensor may have a more significant low tensor Q-rank structure than that of low tubal-rank structure. Specifically, maximizing the variance of singular value distribution leads to Variance Maximization Tensor Q-Nuclear norm (VMTQN), while minimizing the value of nuclear norm through manifold optimization leads to Manifold Optimization Tensor Q-Nuclear norm (MOTQN). Moreover, we apply these two models to the low rank tensor completion problem, and then give an effective algorithm and briefly analyze why our method works better than TNN based methods in the case of complex data with low sampling rate. Finally, experimental results on real-world datasets demonstrate the superiority of our proposed model in the tensor completion problem with respect to other tensor rank regularization models.

报告人简介：林宙辰，北京大学博士，IAPR Fellow，IEEE Fellow, CSIG Fellow，国家杰出青年科学基金的获得者,现任北京大学教授，中国图象图形学学会机器视觉专委会主任，中国自动化学会模式识别与机器智能专委会副主任。主要研究方向机器学习，模式识别，计算机视觉，图像处理，数值优化等，发表学术论文 260 余篇，专著 4 部， Google Scholar 引用次数高达 25000 余次。曾多次担任 ACML, ACCV, CVPR, ICCV, NIPS/NeurIPS, AAAI, IJCAI, ICLR 和 ICML 领域主席。他目前是 ICPR 2022 的程序共同主席，ICML 2022, NeurIPS 2022 和 CVPR 2023 高级领域主席。他曾任 IEEE Transactions on Pattern Analysis and Machine Intelligence 的副主编，目前是 International Journal of Computer Vision and Optimization Methods and Software 的副主编。

Multi-linear PageRank：Uniqueness and Algorithms

黎稳　教授

华南师范大学

摘要：Multi-linear PageRank is a generalization of PageRank, which can be applied to Data clustering, Hypergraph partitioning et al. In this talk we give uniqueness of the PageRank vector and propose some algorithms for solving multi-linear PageRank. Numerical examples are given to illustrate the efficiency of the proposed algorithms.

报告人简介：黎稳，华南师范大学教授、博士生导师、华南师范大学数学科学学院院长。广东省数据科学工程研究中心副主任、中国数学会理事、广东省数学学会副理事长、广东省工业与应用数学学会副理事长、曾任广东省计算数学会副理事长，广东省"千百十"人才工程学术带头人。主要研究方向为：数值代数与应用；互补问题的理论与数值分析；张量理论及其应用。已经在国际著名学术刊物 Numer Math, SIAM J. Optim, SIAM J. Matrix Anal Appl, J. Sci Comput,《中国科学》（中、英文版）、《科学通报》（中、英文版）等学术刊物发表学术论文 190 多篇。曾经获得广东省科学技术奖二等奖（排名第一）。主持国家自然科学基金 6 项，其中连续主持国家自然科学基金面上项目 5 项，主持教育部博士点基金与广东省自然科学基金项目 7 项，广东省高校创新基金 1 项、广东省普通高校创新团队 1 项、广东省普通高校省级重大项目 1 项、广东省优秀人才基金 2 项。

Learning Diagonal Gaussian Mixture Models and Incomplete Tensor Decompositions

聂家旺　教授

加州大学圣地亚哥分校

摘要：This talk discusses how to learn parameters in diagonal Gaussian mixture models. The problem can be formulated as computing incomplete symmetric tensor decompositions. We use generating polynomials to compute incomplete symmetric tensor decompositions and approximations. Then the tensor approximation method is used to learn diagonal Gaussian mixture models. We also do the stability analysis. When the first and third order moments are sufficiently accurate, we show that the obtained parameters for the Gaussian mixture models are also highly accurate.
This is a joint work with Bingni Guo and Zi Yang.

报告人简介：聂家旺，加州大学圣地亚哥分校教授，湘潭大学兼职教授。他长期从事多项式优化、凸代数几何和张量计算等领域的研究，做出了一系列突破性的工作，主要的学术成果包括：提出了求解多项式优化全局最优解的精确松弛系列并证明了它的紧性;给出了凸半代数集可被 SDP 表示的充分性与必要性条件;建立了多项式优化中局部最优性条件与全局最优性条件之间的联系; 给出了多项式优化中的拉格朗日乘子表示定理;提出了生成多项式作为计算张量分解和低秩逼近的新方法。在 SIAM 系列, MP, FoCM 等学术期刊上，发表论文 60 余篇，目前担任 JORSC,COAP,MOR,SIMAX 等期刊的编委。他先后获得国际数学规划学会 Tucker Prize Finalist 奖 (2009)，Hellman Fellowship (2009)，美国科学基金会 Career 奖 (2009), INFORMS 优化青年学者奖 (2014), 2017 年度长江学者，SIAM 线性代数最佳论文奖 (2018). 2021 年 5 月，聂家旺教授因其在多项式优化、凸代数几何和张量计算等方面的突出贡献，荣膺"冯康科学计算奖"。

Dimension Reduction for Covariates in Network Data

赵俊龙　教授

北京师范大学

摘要：A problem of major interest in network data analysis is to explain the strength of connections using context information. To achieve this, we introduce a novel approach, called network supervised dimension reduction, in which covariates are projected onto low-dimensional spaces to reveal the linkage pattern without assuming a model. We propose a new loss function for estimating the parameters in the resulting linear projection, based on the notion that closer proximity in the low-dimension projection corresponds to stronger connections. Interestingly, the convergence rate of our estimator is found to depend on a network effect factor, which is the smallest number that can partition a graph in a manner similar to the graph colouring problem. Our method has interesting connections to principal component analysis and linear discriminant analysis, which we exploit for clustering and community detection. The proposed approach is further illustrated by numerical experiments and analysis of a pulsar candidate's dataset from astronomy.

报告人简介：赵俊龙，北京师范大学统计学院教授、博士生导师，应用统计系主任。从事数理统计和机器学习相关研究，包括：高维数据分析、统计机器学习、稳健统计等。 在统计学各类期刊发表 SCI 论文四十余篇，部分结果发表在统计学国际顶级期刊 Journal of the Royal Statistical Society: Series B (JRSSB), The Annals of Statistics (AOS), Journal of American Statistical Association (JASA), Biometrika 以及领域重要期刊 Statistica Sinica, Statistics and Computing, Bernoulli, Computations Statistic & Data Analysis 等。主持多项国家自然科学基金面上项目，自然科学基金青年基金项目，教育部人文社科基金等科研项目。2013年获得北京航空航天大学"蓝天科研新星"。赵教授是中国现场统计学会高维数据分会理事，北京应用统计学会理事、北京大数据学会常务理事，美国数学评论(Math review) 评论员，以及众多国际国内期刊审稿人。

Robust Tensor Completion: Equivalent Surrogates, Error Bounds and Algorithms

白敏茹　教授

湖南大学

摘 要： Robust Low-Rank Tensor Completion (RTC) problems have received considerable attention in recent years such as signal processing and computer vision. In this paper, we focus on the bound constrained RTC problem for third-order tensors which recovers a low-rank tensor from partial observations corrupted by impulse noise. A widely used convex relaxation of this problem is to minimize the tensor nuclear norm for low rank and the ℓ_1-norm for sparsity. However, it may result in biased solutions. To handle this issue, we propose a nonconvex model with a novel nonconvex tensor rank surrogate function and a novel nonconvex sparsity measure for RTC problems under limited sample constraints and two bound constraints, where these two nonconvex terms have a difference of convex functions structure. Then, a proximal majorization-minimization (PMM) algorithm is developed to solve the proposed model and this algorithm consists of solving a series of convex subproblems with an initial estimator to generate a new estimator which is used for the next subproblem. Theoretically, for this new estimator, we establish a recovery error bound for its recoverability and give the theoretical guarantee that lower error bounds can be obtained when a reasonable initial estimator is available. Then, by using the Kurdyka-L ojasiewicz property exhibited in the resulting problem, we show that the sequence generated by the PMM algorithm globally converges to a critical point of the problem. Extensive numerical experiments including color images and multispectral images show the high efficiency of the proposed model

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Rank-*R* Positive Hermitian Approximation Algorithms and Positive Hermitian Decompositions of Hermitian Tensors

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摘要：Hermitian tensor is regarded as an extension of Hermitian matrix and can be used to represent quantum mixed state. In quantum information, the problem of separability discrimination and decomposition of quantum mixed state is still an important and hard problem. In this paper, we deduce the gradient of the approximation function, propose three algorithms: a negative gradient algorithm and a BFGS algorithm for rank-R positive Hermitian approximation of Hermitian tensors, and a separability discrimination and decomposition algorithm for Hermitian tensors. According to the Taylor formula and the convexity analysis, we prove the effectiveness of the algorithm. Numerical examples also verify the correctness of the theoretical analysis and the effectiveness of algorithms. They show that BFGS algorithm can be used to the separability discrimination and the positive Hermitian decomposition, as well as to obtain a rank positive Hermitian decomposition. Compared with the semidefinite relaxation algorithm, the BFGS algorithm has the advantages of less running time and solving the decomposition of higher-order or higher-dimensional Hermitian tensors.

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北京交通大学数学与统计学院简介

北京交通大学数学与统计学院成立于2022年3月,前身始于1960年2月,北方交通大学应用理学系成立,设立了应用数学专业,1986年10月数学系成立,1996年7月合并成立文理学院,1998年成立理学院。近20年数学学科在学科发展、人才培养和科研上取得了突出成绩。

数学与统计学院下设4个系、1个虚体研究机构：信息与计算科学系、数学与应用数学系、统计与运筹系、数据科学系,北京交通大学基础与交叉科学研究院（虚体）。拥有信息与计算科学、统计学均获、数学与应用数学3个本科专业。数学、统计学2个一级学科博士点,涵盖基础数学、计算数学、概率论与数理统计、应用数学、运筹学与控制论、统计学等6个方向,以及系统科学1个二级学科博士点,设有数学学科博士后流动站,获信息与交通运筹学111创新引智基地。统计与运筹学进入ESI全球学科排名前5%,连续3年QS世界大学学科排名中位居前200,数学位居前300,为我校学科创新融合发展和"双一流"建设做出了重要的贡献。学院拥有统计实验中心、数据科学与工程实验室、科学计算中心校级重点实验室等科研平台,正积极筹建统计综合实验平台,冲击教育部重点实验室。

学院有专职教师83人,包括中国科学院院士1人、北京市教学名师2人、北京市青年教学名师2人,博士生导师31人、硕士生导师72人,全职教授26人、副教授35人,80%有一年以上出国研修经历,博士学位教师占82%。建设有省部级本科金课1门,研究生专业基础课"专业金课"4门,（现代分析基础、代数学基础、拓扑与几何基础、概率论基础）。在专业建设上,信息与计算科学、统计学2个专业获评国家级一流本科专业建设点,数学与应用数学获评北京市一流本科专业。学院拥有高水平师资队伍,发挥运筹学与控制论、应用数学、统计等学科优势,活跃在应用研究前沿,参与了交叉学科研究,应用组合学与编码等理论对信息传输、信息安全、网络等实际问题进行研究,为社会发展、行业标准制定提供了科学支撑。学院近5年主持国家自然基金重点类项目4项,省部级及以上科技成果奖1项。主办高水平国际学术会议40余场,学术交流320余场,国外学者报告140余场。