# 张量优化与数据科学研讨会

# 程

# 序

# 册

主办单位：南开大学陈省身数学研究所

南开大学数学交叉科学中心

协办单位：中国运筹学会数学规划分会

2023 年 4 月 14 日-17 日

中国-天津

# 一、会议时间

2023 年 4 月 14 日 10:00-20:00，南开大学八里台校区嘉园宾馆报到。4 月 15 日-- 4 月 16 日开会，4 月 17 日离会。

# 二、会议组织

**会议学术委员会主任：**

祁力群（杭州电子科技大学）

戴彧虹（中国科学院数学与系统科学研究院）

**会议组织委员会：**

杨庆之（南开大学）

魏益民（复旦大学）

黎　稳（华南师范大学）

黄正海（天津大学）

**会议秘书：**

李红琴（南开大学）

方园周（南开大学）

# 三、会议日程

**会场地点：省身楼 2 楼 216 教室(主会场)；214 教室(分会场)。**

| 日 期 | 时 间 | 题 目 | 报告人 | 主持人 |
|---|---|---|---|---|
| 15 日<br>上午<br>(216) | | | | |
| | 08:30-09:00 | **开幕式及合影** | | 杨庆之<br>魏益民 |
| | 09:00-09:40 | **Dual Quaternion and Augmented Quaternion** | **祁力群**<br>杭州电子科技大学 | 徐大川 |
| | 09:40-10:20 | **Optimization with Least Constraint Violation** | **戴彧虹**<br>中国科学院数学与系统科学研究院 | 韩德仁 |
| 10:20-10:30 茶 歇 | | | | |
| 15 日<br>上午<br>(216) | | | | |
| | 10:30-11:00 | **A Deep Monte Carlo Local Search Method for Binary Optimization** | **文再文**<br>北京大学 | 凌晨 |
| | 11:00-11:30 | **再探增广拉格朗日法** | **丁 超**<br>中国科学院数学与系统科学研究院 | |

| | | | | |
|---|---|---|---|---|
| | 11:30-12:00 | **Stochastic regularized Newton methods for nonlinear equations** | **王　晓**<br>鹏城实验室 | |
| **日 期** | **时　间** | **题　目** | **报告人** | **主持人** |
| 15 日<br>下午<br>(216) | | | | |
| | 02:30-03:00 | **Approximation strategy based on the T-product for third-order quaternion tensors with application to color video compression** | **倪谷炎**<br>国防科技大学 | 黎稳 |
| | 03:00-03:30 | **Low-rank quaternion tensor completion for color video recovery via a novel factorization strategy** | **张立平**<br>清华大学 | |
| | 03:30-04:00 | **Low-rank Tensor Train Decomposition Using Tensor Sketch** | **陈中明**<br>杭州电子科技大学 | |
| 4:00-4:15 茶　歇 | | | | |
| 15 日<br>下午<br>(216) | | | | |
| | 04:15-04:45 | **Practical Sketching Algorithms for Low-Rank Tucker Approximation of Large Tensors** | **喻高航**<br>杭州电子科技大学 | 罗自炎 |
| | 04:45-05:15 | **Accelerated Doubly Stochastic Gradient Descent for Tensor CP Decomposition** | **崔春风**<br>北京航空航天大学 | |

| 日 期 | 时 间 | 题 目 | 报告人 | 主持人 |
|---|---|---|---|---|
| 15 日<br>下午<br>(214) | | | | |
| | 02:30-03:00 | **Fourier sum of squares on finite abelian groups** | **叶 科**<br>中国科学院数学与系统科学研究院 | 刘新为 |
| | 03:00-03:30 | **Discrete approximation for two-stage stochastic variational inequalities** | **孙海琳**<br>南京师范大学 | |
| | 03:30-04:00 | **Primal Dual Alternating Proximal Gradient Algorithms for Nonsmooth Nonconvex Minimax Problems with Coupled Linear Constraints** | **徐 姿**<br>上海大学 | |
| 4:00-4:15 茶 歇 | | | | |
| 15 日<br>下午<br>(214) | | | | |
| | 04:15-04:45 | **New gradient methods for smooth unconstrained optimization problems** | **孙 聪**<br>北京邮电大学 | 郦旭东 |
| | 04:45-05:15 | **A complete solution to Saad's open problem** | **胡胜龙**<br>杭州电子科技大学 | |

| 日 期 | 时 间 | 题 目 | 报告人 | 主持人 |
|---|---|---|---|---|
| 16 日<br>上午<br>(216) | | | | |
| | 08:30-09:10 | **Bridging Distributional and Risk-sensitive Reinforcement Learning with Provable Regret Bounds**<br>**线上，腾讯会议号：243297387** | **罗智泉**<br>香港中文大学（深圳） | 杨庆之 |
| | 09:10-09:50 | **机理与数据融合的计算成像** | **董 彬**<br>北京大学 | 吴春林 |
| 9:50-10:05 茶 歇 | | | | |
| 16 日<br>上午<br>(216) | | | | |
| | 10:05-10:35 | **Noda Iteration for Computing Generalized Tensor Eigenpair** | **魏益民**<br>复旦大学 | 范金燕 |
| | 10:35-11:05 | **Multilinear Pseudo-PageRank for Hypergraph Partitioning** | **陈艳男**<br>华南师范大学 | |
| | 11:05-11:35 | **Tensor Completion via Tensor Train Based Low-Rank Quotient Geometry under a Preconditioned Metric** | **魏 轲**<br>复旦大学 | |

| 日 期 | 时 间 | 题 目 | 报告人 | 主持人 |
|---|---|---|---|---|
| 16 日<br>下午<br>(216) | | | | |
| | 02:00-02:30 | **Formulating a generalized multilinear game as a vertical tensor complementarity problem** | **黄正海**<br>天津大学 | 于波 |
| | 02:30-03:00 | **On polynomial-time approximation of the tensor nuclear p-norm** | **江 波**<br>上海财经大学 | |
| | 03:00-03:30 | **A randomized singular value decomposition for third-order oriented tensors** | **解朋朋**<br>中国海洋大学 | |
| 3:30-3:45 茶 歇 | | | | |
| 16 日<br>下午<br>(216) | | | | |
| | 03:45-04:15 | **Co-positivity of tensors and Stability conditions of CP conserving two-Higgs-doublet potentia** | **宋义生**<br>重庆师范大学 | 白敏茹 |
| | 04:15-04:45 | **Singular Value Decomposition of Dual Matrices and its Application to Traveling Wave Identification in the Brain** | **丁维洋**<br>复旦大学 | |
| | 04:45-05:15 | **Two Heuristics Solving Low Tensor Train Rank Tensor Completion** | **唐云飞**<br>南开大学 | |

| 日 期 | 时 间 | 题 目 | 报告人 | 主持人 |
|---|---|---|---|---|
| 16 日<br>下午<br>(214) | | | | |
| | 02:00-02:30 | **Finite-Step Convergence of Two Algorithms for L_1-Norm PCA** | **杨宇宁**<br>广西大学 | 韩乔明 |
| | 02:30-03:00 | **Efficient algorithms for Tucker decomposition via approximate matrix multiplication** | **车茂林**<br>西南财经大学 | |
| | 03:00-03:30 | **Proximal linearization methods for Schatten p-quasi-norm minimization** | **曾 超**<br>南开大学 | |
| 3:30-3:45 茶 歇 | | | | |
| 16 日<br>下午<br>(214) | | | | |
| | 03:45-04:15 | **Splitting Method for Support Vector Machines in Reproducing Kernel Banach Spaces** | **叶 颀**<br>华南师范大学 | 张新珍 |
| | 04:15-04:45 | **Convergence of gradient-based block coordinate descent algorithms for non-orthogonal joint approximate diagonalization of matrices** | **李建泽**<br>大数据研究院<br>（深圳） | |
| | 04:45-05:15 | **两类 PDE 最优控制问题中的优化算法设计** | **乐航睿**<br>南开大学 | |

**注：会议用餐在嘉园，早餐：7:30-8:20，午餐：12:00-13:00，晚餐：18:00-19:00。**

# 四、报告简介

## 1. Dual Quaternion and Augmented Quaternion

报告人：祁力群

单　位：杭州电子科技大学

摘　要：In this talk, I will first report our result on dual quaternion Hermitian matrices. We showed that an n x n dual quaternion Hermitian matrix has exactly n eigenvalues, which are dual numbers. This matrix is positive semidefinite if and only if these eigenvalues are nonnegative. We applied this result to formation control study, which is important for UAV research. Then I will report our result on augmented quaternions. We proposed augmented quaternions and formulated two classical robotic research problems – the hand-eye calibration problem and the simultaneous location and mapping problem as augmented unit quaternion optimization problems. Comparing with the unit dual quaternion optimization model, the augmented unit quaternion optimization model keeps smoothness and reduces the size of the problem. We explore these two directions from two different points of view. In this talk, I will explain these two different points of view.

## 2. Optimization with Least Constraint Violation

报告人：戴彧虹

单　位：中国科学院数学与系统科学研究院

摘　要：Study about theory and algorithms for nonlinear programming usually assumes the feasibility of the problem. However, there are many important practical nonlinear programming problems whose feasible regions are not known to be nonempty or not. This leads to a class of problems called optimization with least constraint violation.

Firstly, the optimization problem with least constraint violation is proved to be

an Lipschitz equality constrained optimization problem and an elegant necessary optimality condition, named as L-stationary condition, is established. Properties of the classical penalty method for this Lipschitz minimization problem are developed and the proximal gradient method for the penalized problem is studied.

Secondly, the optimization problem with least constraint violation is reformulated as an MPCC problem and a local minimizer of the MPCC problem is proved to an M-stationary point. The smoothing Fischer-Burmeister function method is constructed and analyzed for solving the related MPCC problem.

Thirdly, the solvability of the dual of the optimization problem with least constraint violation is investigated. The optimality conditions for the problem with least constraint violation are established in term of the augmented Lagrangian. Moreover, it is proved that the augmented Lagrangian method can find an approximate solution to the optimization problem with least constraint violation and has linear rate of convergence under an error bound condition.

Finally, the constrained convex optimization problem with the least constraint violation is considered and analyzed under a general measure function. Several other related works on the optimization problem with least constraint violation will also be mentioned.

## 3. Bridging Distributional and Risk-sensitive Reinforcement Learning with Provable Regret Bounds

**报告人：罗智泉**

**单　位：香港中文大学（深圳）**

**摘　要：** Risk-sensitive decision-making is crucial in high-stakes applications, such as finance, medical treatment, and operations research. In these scenarios, decision-makers aim to maximize a risk measure of the return distribution, rather than simply

maximizing the expected return, a.k.a. Risk-sensitive reinforcement learning (RSRL). As the first risk measure applied to RSRL, the exponential risk measure has been successfully applied in various domains. However, current approaches involve complicated algorithmic designs and regret analysis to handle the non-linearity of the exponential risk measure.

To tackle these challenges, we propose a novel distributional reinforcement learning (DRL) algorithms for RSRL with regret guarantee. Our algorithm does not involve complicated bonus design to guide exploration, and enjoy a simpler and more interpretable regret analysis. We build a risk-sensitive distributional dynamic programming. Furthermore, we provide a regret upper bound of the algorithm via distributional optimism.

## 4. 机理与数据融合的计算成像

**报告人：董　彬**

**单　位：北京大学**

**摘　要：**计算成像是我们观察和理解自然界的重要途径，它关注如何高效地感知自然现象、获取数据并重建高质量的图像，以支持人们的研究和决策。计算成像涵盖了三个关键环节：图像感知、图像重建和图像分析。传统上，图像感知主要依赖硬件设计，而图像重建和分析则主要涉及数学和统计方法。长期以来，这三个环节的发展相对独立，相互融合的程度较低。然而，在机器学习（特别是深度学习）取得显著进展的当下，这种情况正在逐步改变。

本报告主要探讨深度学习为计算成像带来的机遇和挑战，介绍如何将传统的图像重建算法与深度学习方法相结合，设计出数据驱动和任务驱动的成像算法，从而实现计算成像三个环节的有机融合。报告的最后部分将从更宏观的角度讨论计算成像在生命科学和医学前沿研究中的重要性，以及其未来发展方向。

## 5. Efficient algorithms for Tucker decomposition via approximate matrix multiplication

报告人：车茂林

单　位：西南财经大学

摘　要：In this talk, we develop fast and efficient algorithms for computing Tucker decomposition with a given multilinear rank. By combining random projection and the power scheme, we propose two efficient randomized versions for the truncated high-order singular value decomposition (T-HOSVD) and the sequentially T-HOSVD (ST-HOSVD), which are two common algorithms for approximating Tucker decomposition. To reduce the complexities of these two algorithms, fast and efficient algorithms are designed by combining two algorithms and approximate matrix multiplication. The theoretical results are also achieved based on the bounds of singular values of standard Gaussian matrices and the theoretical results for approximate matrix multiplication. Finally, the efficiency of these algorithms are illustrated via some test tensors.

## 6. Multilinear Pseudo-PageRank for Hypergraph Partitioning

报告人：陈艳男

单　位：华南师范大学

摘　要：Hypergraphs have the capability of modeling connections among objects according to their inherent multiwise similarity and affinity. Hence, many crucial applications of hypergraph have been mined in science and engineering. In this talk, we build a bridge between uniform hypergraphs and PageRank. Starting from the nonnegative adjacency tensor of a uniform hypergraph, we establish the multilinear pseudo-PageRank model, which is formulated as a multilinear system with nonnegative constraints. The coefficient tensor of the multilinear system is a kind of Laplacian tensor of the uniform hypergraph and no dangling corrections are involved. Then, a gradient projection algorithm is utilized for solving the multilinear pseudo-PageRank problem, of which solutions exist but may not be unique. By using the Lojasiewicz property, we

analyze the global and local convergence of the proposed gradient projection algorithm. Numerical experiments illustrate that the proposed multilinear pseudo-PageRank method is powerful and effective for semi-supervised and unsupervised hypergraph partitioning.

## 7. Low-rank Tensor Train Decomposition Using Tensor Sketch

报告人：陈中明

单　位：杭州电子科技大学

**摘　要：** Tensor train decomposition is one of the most powerful approaches for processing high-dimensional data. For low-rank tensor train decomposition of large tensors, the alternating least square algorithm is widely used by updating each core tensor alternatively. However, it may suffer from the curse of dimensionality due to the large scale of subproblems. In this paper, a novel randomized algorithm is proposed for low-rank tensor train decomposition by using the technology of Tensor Sketch, which allows for efficient implementation via fast Fourier transform. The theoretical lower bounds of sketch size are estimated based on the properties of sparse embedding matrices. Numerical experiments on synthetic and real-world data also demonstrate the effectiveness and efficiency of the proposed algorithm.

## 8. Accelerated Doubly Stochastic Gradient Descent for Tensor CP Decomposition

报告人：崔春风

单　位：北京航空航天大学

**摘　要：** In this talk, we focus on the acceleration of the doubly stochastic gradient descent method for computing the CANDECOMP/PARAFAC (CP) decomposition of tensors. This optimization problem has N blocks, where N is the order of the tensor.

Under the doubly stochastic framework, each block subproblem is solved by the vanilla stochastic gradient method. However, the convergence analysis requires the variance to converge to zero, which is hard to check in practice and may not hold in some experiments. In this paper, we propose accelerating the stochastic gradient method by the Momentum acceleration and the Variance Reduction technique, denoted as DS-MVR. Theoretically, the convergence of DS-MVR only requires the variance to be bounded. We show the convergence and convergence rate of DS-MVR. Numerical experiments on four real-world datasets show that our proposed algorithm can get better results compared with the baselines.

## 9. 再探增广拉格朗日法

报告人：丁　超

单　位：中国科学院数学与系统科学研究院

**摘　要：**自 1969 年由 M.R. Hestenes 和 M.J.D. Powell 提出以来，增广拉格朗日法以其深刻的优化理论以及求解优化问题时优异的数值效果，受到数学优化、机器学习等不同领域学者的广泛关注，并已被用于许多著名优化求解器以提高求解许多大规模约束优化问题的数值效果。在本讲座中，我们将结合矩阵优化最新理论结果，介绍增广拉格朗日法在求解非线性半正定优化、黎曼流形上的非光滑优化的研究进展。

## 10. Singular Value Decomposition of Dual Matrices and its Application to Traveling Wave Identification in the Brain

报告人：丁维洋

单　位：复旦大学

**摘　要：**Matrix factorization in dual number algebra, a hypercomplex system, has been applied to kinematics, mechanisms, and other fields recently. We develop an approach to identify spatiotemporal patterns in the brain such as traveling waves using the singular value decomposition of dual matrices in this paper. Theoretically, we

propose the compact dual singular value decomposition (CDSVD) of dual complex matrices with explicit expressions as well as a necessary and sufficient condition for its existence. Furthermore, based on the CDSVD, we report on the optimal solution to the best rank-k approximation under a newly defined Froubenius norm in dual complex number system. The CDSVD is also related to the dual Moore-Penrose generalized inverse. Numerically, comparisons with other available algorithms are conducted, which indicate the less computational cost of our proposed CDSVD. Next, we employ experiments on simulated time-series data and a road monitoring video to demonstrate the beneficial effect of infinitesimal parts of dual matrices in spatiotemporal pattern identification. Finally, we apply this approach to the large-scale brain fMRI data and then identify three kinds of traveling waves, and further validate the consistency between our analytical results and the current knowledge of cerebral cortex function.

## 11. On polynomial-time approximation of the tensor nuclear p-norm

报告人：关劼文

单　位：上海财经大学

摘　要：The tensor nuclear $p$-norm is an important research object in tensor computation and analysis, and it has found successful and effective applications in some machine learning problems. Due to its NP-hard computational nature, the study on its polynomial-time approximation is necessary. However, to the best of our knowledge, this topic is still very under-explored, and the best-known polynomial-time approximation ratio for the tensor nuclear $p$-norm is still much inferior to that for its dual norm, the tensor spectral $p$-norm, which shows room for improvement. In this paper, we design deterministic and randomized polynomial-time approximation algorithms for the tensor nuclear $p$-norm based on two key techniques introduced below, with more importance and emphasis associated to the former, to bridge this gap. The first technique is a comprehensive and careful treatment to the $p\rightarrow q$ norm involved in the dual formulation of the tensor nuclear $p$-norm and a series of ensuing problems whose ultimate goal is to derive a constant-factor semidefinite

program relaxation of the tensor nuclear $p$-norm but with uncountably many semidefinite constraints, and techniques in robust optimization as well as those in modern convex optimization developed by Ben-Tal and Nemirovski are utilized therein. The second technique concerns the uncountability issue appeared above which is actually caused by the uncountable cardinality of the unit $\ell_p$ sphere and studies the $\ell_p$ sphere covering problem, namely the design of hitting sets for the unit $\ell_p$ sphere (i.e., a set of representative points on the sphere, roughly speaking). As main products, we construct deterministic and randomized polynomial-sized hitting sets for the unit $\ell_p$ sphere with their hitting values having the capability to help bridge the aforementioned gap. As a result of the above developments, deterministic and randomized polynomial-time approximation algorithms for the tensor nuclear $p$-norm can then be naturally derived, and we further show their approximation ratios match the best-known ones of the tensor spectral $p$-norm, its dual norm, as desired. We believe our methodology (resp. results) shall deliver useful and far-reaching insights (resp. have further applications) for other related problems.

## 12. A complete solution to Saad's open problem

报告人：胡胜龙

单　位：杭州电子科技大学

摘　要：In 2009, von Neumann prize-winner Yousef Saad proposed the open problem on characterizing the convergence rate of the classical alternating polar decomposition method for low rank orthogonal tensor approximation problem. Actually, this problem was initiated by Gene Golub in 2001 for the rank one case, and received considerable study in the past twenty years. In 2015, Wolfgang Hackbusch presented concrete examples showing that the convergence rate may be sublinear, linear and superlinear. In this talk, we show that for a generic tensor, the algorithm converges linearly without any further assumption.

## 13. Formulating a generalized multilinear game as a vertical

**tensor complementarity problem**

报告人：黄正海

单　位：天津大学

摘　要：In this talk, we generalize the multilinear game where the payoff tensor of each player is fixed to the generalized multilinear game where the payoff tensor of each player is selected from a nonempty set of tensors. When all involved sets of tensors are finite, we show that finding a Nash equilibrium point for the generalized multilinear game is equivalent to solving a vertical tensor complementarity problem, and establish a one-to-one correspondence between the Nash equilibrium point of the game and the solution of the vertical tensor complementarity problem.

## 14. Convergence of gradient-based block coordinate descent algorithms for non-orthogonal joint approximate diagonalization of matrices

报告人：李建泽

单　位：深圳大数据研究院

摘　要：In this talk, we propose a gradient-based block coordinate descent (BCD-G) framework to solve the joint approximate diagonalization of matrices defined on the product of the complex Stiefel manifold and the special linear group. Instead of the cyclic fashion, we choose a block optimization based on the Riemannian gradient. To update the first block variable in the complex Stiefel manifold, we use the well-known line search descent method. To update the second block variable in the special linear group, based on four kinds of different elementary transformations, we construct three classes: GLU, GQU and GU, and then get three BCD-G algorithms: BCD-GLU, BCD-GQU and BCD-GU. We establish the global and weak convergence of these three algorithms using the Lojasiewicz gradient inequality under the assumption that the iterates are bounded. We also propose a gradient-based Jacobi-type framework to solve the joint approximate diagonalization of matrices defined on the special linear group.

As in the BCD-G case, using the GLU and GQU classes of elementary transformations, we focus on the Jacobi-GLU and Jacobi-GQU algorithms and establish their global and weak convergence. All the algorithms and convergence results described in this paper also apply to the real case. This is a joint work with Konstantin Usevich and Pierre Comon.

## 15. Approximation strategy based on the T-product for third-order quaternion tensors with application to color video compression

报告人：倪谷炎

单　位：国防科技大学

摘　要：Following up the ideas of T-product algebra for third-order real tensors, this paper aims to establishing an approximation strategy based on the T-product for third-order quaternion tensors. First, we constructively prove the existence of the tensor-quaternion singular value decomposition (t-QSVD) for third-mode symmetric quaternion tensors, and provide a way to compute the t-QSVD via fast Fourier transforms. Further, we propose a T-product based compression strategy for any given third-order quaternion tensor. Last, we conduct numerical simulations on the color video compression, which demonstrate that the T-product based compression strategy is superior to the QT-product based one proposed by Qin, Ming and Zhang (Appl. Math. Lett., 123 (2022), 107597), in terms of visualization performance and quantitative assessment.

## 16. Co-positivity of tensors and Stability conditions of CP conserving two-Higgs-doublet potentia

报告人：宋义生

单　位：重庆师范大学

摘　要：In this paper, we mainly study the co-positivity of　a class of tensor with

two free parameters defined by CP conserving two-Higgs-doublet model in particle physics, which can be used to determine the vacuum stability of scalar potential for two-Higgs-doublet model with explicit CP conservation. We break down the co-positivity problem into three minimum problems, and successfully obtain the analytical sufficient and necessary conditions of such a problem with the help of the corresponding theory and methods of higher order tensors.

## 17. New gradient methods for smooth unconstrained optimization problems

报告人：孙 聪

单 位：北京邮电大学

摘 要：In this talk, a new gradient method for unconstrained optimization problem is proposed, where the stepsizes are updated in a cyclic way, and the Cauchy step is approximated by the quadratic interpolation. Combined with the adaptive non-monotone line search technique, we prove the global convergence of this method. Moreover, the algorithms have sublinear convergence rate for general convex functions and R-linear convergence rate for strongly convex problems. The numerical results show that our proposed algorithm outperforms the benchmark methods.

## 18. Discrete approximation for two-stage stochastic variational inequalities

报告人：孙海琳

单 位：南京师范大学

摘 要：In this paper, the discrete approximation of two-stage stochastic variational inequalities has been investigated when the second stage problem has multiple solutions. First, a discrete approximation scheme is given by a series of models with the aid of merit functions. After that, the convergence relationships between these models are analysed, which therefore yields the convergence guarantee of the proposed discrete

approximation scheme. Finally, we use the well-known progressive hedging algorithm to report some numerical results and to validate the effectiveness of the discrete approximation approach.

## 19. Two Heuristics Solving Low Tensor Train Rank Tensor Completion

报告人：唐云飞

单　位：南开大学

摘　要：In this talk, we consider the low rank tensor completion problem based on the tensor train (TT) tank. We propose two models for the tensor completion problem, one is based on the nuclear norm heuristic, and the other is based on the factorization heuristic. We apply the ADMM and Douglas-Rachford splitting technique to the nuclear norm model. And for the factorization model we utilize the alternating linear scheme (ALS) and the modified alternating linear scheme (MALS), which are special block coordinate descent methods for minimization tasks in the TT format, to reduce the computation cost of the subproblem. We test our algorithms on synthetic data and color images and compare them with some popular tensor completion methods. The simulation results show that our algorithms are competitive.

## 20. Stochastic regularized Newton methods for nonlinear equations

报告人：王　晓

单　位：鹏城实验室

摘　要：In this talk we introduce stochastic regularized Newton methods to find zeros of nonlinear equations, whose exact function information is normally expensive to calculate but approximations can be easily accessed via calls to stochastic oracles. To handle the potential singularity of Jacobian approximations, we compute a regularized Newton step at each iteration. Then we take a unit step if it can be accepted by an

inexact line search condition, and a preset step otherwise. We investigate the global convergence properties and the convergence rate of the proposed algorithm with high probability. We also propose a stochastic regularized Newton method incorporating a variance reduction technique and establishing the corresponding sample complexities in terms of total numbers of stochastic oracle calls to find an approximate solution. Finally, we report some numerical results and demonstrate the promising performances of the two proposed algorithms.

## 21. A Deep Monte Carlo Local Search Method for Binary Optimization

报告人：文再文

单　位：北京大学

摘　要：Binary integer programming problems are ubiquitous in many practical applications, including the maxcut and cheeger cut problem, the multiple-input multiple-output (MIMO) detection problem, etc.  They are NP-hard due to the combinatorial structure. In this talk, we present a policy gradient method using deep Monte Carlo local search. Preliminary numerical results demonstrate the efficiency of our method.

## 22. Tensor Completion via Tensor Train Based Low-Rank Quotient Geometry under a Preconditioned Metric

报告人：魏 轲

单　位：复旦大学

摘　要：Low-rank tensor completion problem is about recovering a tensor from partially observed entries. We consider this problem in the tensor train format and extend the preconditioned metric from the matrix case to the tensor case. The first-order and second-order quotient geometry of the manifold of fixed tensor train rank tensors under this metric is studied in detail. Algorithms, including Riemannian gradient

descent, Riemannian conjugate gradient, and Riemannian Gauss-Newton, have been proposed for the tensor completion problem based on the quotient geometry. It has also been shown that the Riemannian Gauss-Newton method on the quotient geometry is equivalent to the Riemannian Gauss-Newton method on the embedded geometry with a specific retraction.

## 23. Noda Iteration for Computing Generalized Tensor Eigenpair

报告人：魏益民

单　位：复旦大学

摘　要：In this talk, we propose the tensor Noda iteration (NI) and its inexact version for solving the eigenvalue problem of a particular class of tensor pairs called generalized M-tensor pairs. A generalized M-tensor pair consists of a weakly irreducible nonnegative tensor and a nonsingular M-tensor within a linear combination. It is shown that any generalized M-tensor pair admits a unique positive generalized eigenvalue with a positive eigenvector. A modified tensor Noda iteration(MTNI) is developed for extending the Noda iteration for nonnegative matrix eigenproblems. In addition, the inexact generalized tensor Noda iteration method (IGTNI) and the generalized Newton-Noda iteration method (GNNI) are also introduced for more efficient implementations and faster convergence. Under a mild assumption on the initial values, the convergence of these algorithms can be guaranteed. The efficiency of these algorithms is illustrated by numerical experiments.

## 24. A randomized singular value decomposition for third-order oriented tensors

报告人：解朋朋

单　位：中国海洋大学

**摘　要：** The oriented singular value decomposition (O-SVD) proposed by Zeng and Ng provides a hybrid approach to the t-product-based third-order tensor singular value decomposition with the transformation matrix being a factor matrix of the higher order singular value decomposition. Continuing along this vein, this paper explores realizing the O-SVD efficiently by drawing a connection to the tensor-train rank-1 decomposition and gives a truncated O-SVD. Motivated by the success of probabilistic algorithms, we develop a randomized version of the O-SVD and present its detailed error analysis. The new algorithm has advantages in efficiency while keeping good accuracy compared with the current tensor decompositions. Our claims are supported by numerical experiments on several oriented tensors from real applications.

## 25. Primal Dual Alternating Proximal Gradient Algorithms for Nonsmooth Nonconvex Minimax Problems with Coupled Linear Constraints

**报告人：徐 姿**

**单　位：上海大学**

**摘　要：** Nonconvex minimax problems have attracted wide attention in machine learning, signal processing and many other fields in recent years. In this paper, we propose a primal dual alternating proximal gradient (PDAPG) algorithm and a primal dual proximal gradient (PDPG-L) algorithm for solving nonsmooth nonconvex-(strongly) concave and nonconvex-linear minimax problems with coupled linear constraints, respectively. The iteration complexity of the two algorithms are proved to be $O(\epsilon^{-2})$ (resp. $O(\epsilon^{-4})$) under nonconvex-strongly concave (resp. nonconvex-concave) setting and $O(\epsilon^{-3})$ under nonconvex-linear setting to reach an $\epsilon$-stationary point, respectively. To our knowledge, they are the first two algorithms with iteration complexity guarantee for solving the nonconvex minimax problems with coupled linear constraints.

## 26. Finite-Step Convergence of Two Algorithms for $L_1$-Norm PCA

报告人：杨宇宁

单　位：广西大学

摘　要：The classical non-greedy algorithm (NGA) and the recently proposed proximal alternating minimization method with extrapolation (PAMe) for L1-norm PCA are revisited and their finite-step convergence are studied. We first show that the sequence of the objective values generated by NGA will be constant after at most $\left\lceil\frac{F^{\max}}{\tau_0} \right\rceil$ steps, where the stopping point satisfies certain optimality conditions. Then, a slight modification of NGA with improved convergence properties is analyzed. It is shown that the iterative points generated by the modified algorithm will not change after at most $\left\lceil\frac{2F^{\max}}{\tau} \right\rceil$ steps; furthermore, the stopping point satisfies certain optimality conditions if the proximal parameter τ is small enough.

For PAMe, it is proved that the sign variable will remain constant after finitely many steps and the algorithm can output a point satisfying certain optimality condition, if the parameters are small enough and a full rank assumption is satisfied. Moreover, if there is no proximal term on the projection matrix related subproblem, then the iterative points generated by this modified algorithm will not change after at most $\left\lceil\frac{4F^{\max}}{\tau(1-\gamma)} \right\rceil$ steps and the stopping point also satisfies certain optimality conditions, provided similar assumptions as those for PAMe. The full rank assumption can be removed when the projection dimension is one.

## 27. Fourier sum of squares on finite abelian groups

报告人：叶　科

单　位：中国科学院数学与系统科学研究院

**摘　要：** This talk consists of two parts. In the first part, we introduce a framework of certifying the non-negativity of a tensor. Via the Fourier analysis on groups, the problem is equivalent to computing the Fourier sum of squares (FSOS). We will discuss both the theoretical and algorithmic aspects of this problem. The second part is concerned with applications of our framework to combinatorial problems such as pigeon hole principle, MAX-SAT and MAX-CUT.

## 28. Splitting Method for Support Vector Machines in Reproducing Kernel Banach Spaces

**报告人：叶　颀**

**单　位：华南师范大学**

**摘　要：** In this talk, we use the splitting method based on alternating direction method of multipliers (ADMM) for support vector machines (SVM) in reproducing kernel Banach spaces (RKBS) with lower semi-continuous loss functions. Making use of Kurdyka-Lojasiewicz inequality, the iterative sequences obtained by these splitting methods are globally convergent to a stationary point if the loss functions are lower semi-continuous and subanalytic. Finally, several numerical performances demonstrate the effectiveness.

## 29. Practical Sketching Algorithms for Low-Rank Tucker Approximation of Large Tensors

**报告人：喻高航**

**单　位：杭州电子科技大学**

**摘　要：** Low-rank approximation of tensors has been widely used in high-dimensional data analysis. It usually involves singular value decomposition (SVD) of large-scale matrices with high computational complexity. Sketching is an effective data compression and dimensionality reduction technique applied to the low-rank

approximation of large matrices. This talk presents two practical randomized algorithms for low-rank Tucker approximation of large tensors based on sketching and power scheme, with a rigorous error-bound analysis. Numerical experiments on synthetic and real-world tensor data demonstrate the competitive performance of the proposed algorithms.

## 30. 两类 PDE 最优控制问题中的优化算法设计

**报告人：乐航睿**

**单　位：南开大学**

**摘　要：**偏微分方程(PDE)的最优控制旨在最优地控制 PDE 描述的系统或过程来达到特定的目的。这类问题在离散后通常是一个大规模且病态的问题，可能包含非光滑、非线性以及非凸性质，是科学计算中最复杂的问题之一。此报告关注如何用优化算法求解两类 PDE 最优控制，即对流-扩散-反应方程的双线性控制以及热对流控制。我们将会以这两类问题为例，对 PDE 最优控制问题做简单介绍，探讨 PDE 最优控制的优化算法设计可能遇到的问题，并提出一些有效的数值方法。

## 31. Low-rank quaternion tensor completion for color video recovery via a novel factorization strategy

**报告人：张立平**

**单　位：清华大学**

**摘　要：** In this talk, by introducing an extensive quaternion discrete Fourier transformation (QDFT) based on a pure quaternion basis, we propose a novel multiplication principle for third-order quaternion tensor named gQt-product, and then a new SVD is given. With such SVD, we establish two low-rank quaternion tensor completion models to recover the incomplete color video data, and present an alternating least-squared (ALS) algorithm to solve the color video recovery problems. The numerical experiments show that our methods outperform other state-of-the-arts in the recovery accuracy and computational efficiency.

## 32. Proximal linearization methods for Schatten p-quasi-norm minimization

报告人：曾　超

单　位：南开大学

摘　要：Schatten p-quasi-norm minimization has advantages over nuclear norm minimization in recovering low-rank matrices. However, Schatten p-quasi-norm minimization is much more difficult, especially for generic linear matrix equations. We first extend the lower bound theory of Lp minimization to Schatten p-quasi-normminimization. Motivated by this property, we propose a proximal linearization method, whose subproblems can be solved efficiently by the (L)ADMM. The convergence analysis of the proposed method involves the nonsmooth analysis of singular value functions. We give a necessary and sufficient condition for a singular value function to be a Kurdyka–Łojasiewicz function. The subdifferentials of related singular value functions are computed. The global convergence of the proposed method is established under some assumptions. Experiments on matrix completion, Sylvester equation and image deblurring show the effectiveness of the algorithm.