The 11th International Conference on Numerical Optimization and Numerical Linear Algebra

August 8-11, 2017

Yinchuan, Ningxia, China

http://lsec.cc.ac.cn/~icnonla17

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Information for Participants

Conference Hotel and Conference Venue

Hotel:	Vienna Hotel, Yinchuan
	维也纳酒店
Address:	No 461, Shanghai West Road, Yinchuan
	银川市上海西路461号
Venue:	Multi-functional Lecture Hall at 5th Floor, Vienna Hotel
	维也纳酒店五层多功能厅

Arrival

By air: the distance between Yinchuan Airport and the conference hotel is about 33 km. It will cost you about 70 RMB (11 USD c.a.) to take a taxi. For the invited speakers, you will be picked up at the airport, if you have sent your arrival information to the organizing committee.

By train: there is about 2.4 km from Yinchuan railway station to the conference hotel. The taxi fare is about 7 RMB (2 USD c.a.).

On-site Registration

On-site registration will take place at the **lobby of Vienna Hotel, Yinchuan** on **August 7** from **13:00** to **21:00**. You can also register at any other time during the conference, but please contact Ms. Jiping Wu or Mr. Cheng Chen in advance.

Currency

Chinese currency is RMB. The current rate is about 6.77 RMB for 1 US dollar. The exchange of foreign currency can be done at the airport or the banks in Yinchuan. Please keep the receipt of the exchange so that you can change back to your own currency if you have RMB left before you leave China. Please notice that some additional processing fee will be charged if you exchange currency in China.

Contact Information

If you need any help, please feel free to contact

- Ms. Jiping Wu: +86-136-9106-6084 (in Chinese)
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Conference Schedule

August 8, Tuesday

08:30-09:00 Opening Ceremony

- **08:30-08:45 Welcome Address**
- **08:45-09:00 Group Photo**

09:00-10:20 Invited Talks V1
Chair: Ya-xiang Yuan

- **09:00-09:40 Yinyu Ye**, High-Dimensional Learning with Concave Penalty
- **09:40-10:20 Zhaojun Bai**, Can you tell the shapes of objects from the eigenvectors?

10:20-10:40 Coffee Break

10:40-12:00 Invited Talks V2
Chair: Yinyu Ye

- **10:40-11:20 Maxim Ivanov Todorov**, Constraint Qualifications In Vector Semi-Infinite Optimization
- **11:20-12:00 Thorsten Koch**, SCIP-Jack: a solver for Steiner Tree problems in graphs and their relatives

12:00-14:00 Lunch

14:00-15:20 Contributed Talks C1

Chair: Zhaojun Bai

14:00-14:20 **Liwei Zhang**, The Rate of Convergence of the Augmented Lagrangian Method for a Nonlinear Semidefinite Nuclear Norm Composite Optimization Problem

14:20-14:40 **Wenbao Ai**, Narrowing the duality gap of the extended CDT trust-region problem by second-order cone

14:40-15:00 **Andre Milzarek**, A globalized semismooth Newton method for generalized variational inequality problems

15:20-15:40 **Qiang Niu**, Analysis of a new dimension-wise splitting iteration with selective relaxation for saddle point problems

15:20-15:40 Coffee Break

15:40-16:40 Contributed Talks C2

Chair: Maxim Ivanov Todorov

15:40-16:00 **Andreas Loehne**, Calculus of Convex Polyhedra and Polyhedral Convex Functions

16:00-16:20 **Benjamin Weissing**, Vector Linear Programming by Polyhedral Projection Problems

16:20-16:40 **Lizhen Shao**, Approximation of Convex Bodies by Multiple Objective Optimization and an Application in Reachable Sets

16:40-18:00 Contributed Talks C3

Chair: Thorsten Koch

16:40-17:00 **Joachim Heinze**, The Unchanged Changing World of Mathematical Publishing

17:00-17:20 **Shuxiong Wang**, A Low Rank Matrix Decomposition Method for Single-Cell Data Analysis

17:20-17:40 **Yongfeng Li**, Electronic structure calculation using semidefinite programs

18:00 Dinner

August 9, Wednesday

09:00-10:20 Invited Talks V3

Chair: Yuhong Dai

09:00-09:40 **Alfredo Iusem**, On Eigenvalue Complementarity Problems

09:40-10:20 **Shuzhong Zhang**, Block Optimization over Riemannian Manifolds with Linear Constraints

10:20-10:40 Coffee Break

10:40-12:00 Invited Talks V4

Chair: Alfredo Iusem

10:40-11:20 **Wotao Yin**, ADMM/DRS for Infeasible, Unbounded, and Pathological Conic Programs

11:20-12:00 **Xiaoming Yuan**, Partial error bound conditions and the linear convergence rate of ADMM

12:00-14:00 Lunch

14:00-15:20 Contributed Talks C4

Chair: Shuzhong Zhang

14:00-14:20 **George Vazmin**, Searching For Maxima In Multy-Extreme Function

14:20-14:40 **Cong Sun**, A new gradient method improving Yuan's stepsize

14:40-15:00 **Bin Gao**, Parallel Approaches for Orthogonally Constrained Optimization Problems

15:00-15:20 **Jiang Hu**, Adaptive Regularized Newton Method for Riemannian Optimization

15:20-15:40 Coffee Break

15:40-16:40 Contributed Talks C5

Chair: Wotao Yin

15:40-16:00 **Yuan Shen**, An Alternating Minimization Method for Robust Principal Component Analysis

16:00-16:20 **Tingting Wu**, An efficient Peaceman-Rachford splitting method for constrained TGV-shearlet based MRI reconstruction

16:20-16:40 **Ruizhi Zhou**, Anomaly detection in dynamic attributed graphs

16:40-18:00 Contributed Talks C6

Chair: Xiaoming Yuan

16:40-17:00 Anwa Zhou, Tensor Maximal Correlation Problems

17:00-17:20 Cheng Chen, A Multilevel Gradient-Type Framework for Nonlinear Optimization

17:20-17:40 Weikun Chen, Generalized Coefficient Strengthening Cuts for Mixed Integer Programming

17:40-18:00 Haoyang Liu, A Sparse Completely Positive Relaxation of the Modularity Maximization for Community Detection

18:00 Dinner

August 10, Thursday

09:00-10:20 Invited Talks V5

Chair: Xin Liu

- **09:00-09:40** **Serge Gratton**, A primal-dual approach of weak-constrained data assimilation
- **09:40-10:20** **Shoham Sabach**, First Order Methods for Solving Convex Bi-Level Optimization Problems

10:20-10:40 Coffee Break

10:40-12:00 Invited Talks V6

Chair: Serge Gratton

- **10:40-11:20** **Jiawang Nie**, Symmetric Tensor Nuclear Norm
- **11:20-12:00** **Jinyan Fan**, Tensor Eigenvalue Complementarity Problems

12:00-14:00 Lunch

14:00-15:20 Contributed Talks C7

Chair: Shoham Sabach

- **14:00-14:20** **Zhouhong Wang**, An infeasible primal-dual interior point Method for computing the analytic center of an ill-conditioned polytope
- **14:20-14:40** **Liaoyuan Zeng**, Convergence Rate of Gradient Descent Method for Multi-Objective Optimization
- **14:40-15:00** **Liang Zhao**, Limited memory algorithms with cubic regularization
- **15:00-15:20** **Liang Chen**, A Method to Update Factorizations of the KKT Matrices in Active-set Methods

15:20-15:40 Coffee Break

15:40-16:40 Contributed Talks C8

Chair: Jiawang Nie

- **15:40-16:00** **Hailin Sun**, Discrete Approximation of Two-Stage Stochastic and Distributionally Robust Linear Complementarity Problems
- **16:00-16:20** **Bo Jiang**, Vector Transport-Free SVRG with General Retraction for Riemannian Optimization: Complexity Analysis and Practical Implementation
- **16:20-16:40** **Xiaoyu Wang**, Proximal Stochastic Quasi-Newton methods for Constrained Nonconvex Composition Optimization

16:40-17:40 Contributed Talks C9

Chair: Jinyan Fan

- **16:40-17:00** **Kaiping Luo**, High-performance technique for satellite range scheduling
- **17:00-17:20** **Shengguo li**, A fast inverse algorithm for the block tridiagonal Toeplitz matrices and its application to fast train palindromic quadratic eigenvalue problems
- **17:20-17:40** **Qian Dong**, Parallel Subspace Correction Method for Strongly Convex Problem

18:00 Dinner

August 11, Friday

Free to arrange

Abstracts

Part I

Invited Talks

Can you tell the shapes of objects from the eigenvectors?

Zhaojun Bai

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Spectral Clustering based on the eigenvectors of underlying Laplacian of data under study is one of the most important techniques for data analysis. Constrained clustering refers to the clustering with a prior domain knowledge of grouping information. Here relatively few must-link (ML) or cannot-link (CL) constraints are available to specify regions that must be grouped in the same partition or be separated into different ones. With constraints, the quality of clustering could be improved dramatically.

FAST-GE is a recently proposed spectral algorithm for constrained clustering It incorporates the ML and CL constraints into two Laplacian matrices and then minimizes a Rayleigh quotient via solving a generalized eigenproblem. FAST-GE is considered to be simple and scalable. However, there are two unsolved issues. Theoretically, since both Laplacian matrices are positive semi-definite and the corresponding pencil is singular, it is not proven whether the minimum of Rayleigh quotient exists and is equivalent to a generalized eigenproblem. Computationally, existing generalized symmetric definite eigensolvers, such as the locally optimal block preconditioned conjugate gradient (LOBPCG) is not designed for solving the eigenproblem of a singular pencil. In this talk, we provide solutions to these two critical issues. We prove a generalization of Courant-Fischer variational principle for the Laplacian singular pencil. We propose a regularization scheme for the singular pencil so that generalized symmetric definite eigensolvers, such as LOBPCG, are immediately applicable. We will demonstrate the robustness and efficiency of proposed solutions for constrained image segmentation. The proposed theoretical and computational solutions can be applied to eigenproblems of positive semi-definite pencils arising in other machine learning algorithms, such as generalized linear discriminant analysis in dimension reduction and multisurface classification via eigenvectors.

This is a joint work with Chengming Jiang and Huiqing Xie.

Tensor Eigenvalue Complementarity Problems

Jinyan Fan

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In this talk, we discuss tensor eigenvalue complementarity problems. Basic properties of standard and complementarity tensor eigenvalues are discussed. We formulate tensor eigenvalue complementarity problems as constrained polynomial optimization. When one tensor is strictly copositive, the complementarity eigenvalues can be computed by solving polynomial optimization with normalization by strict copositivity. When no tensor is strictly copositive, we formulate the tensor eigenvalue complementarity problem equivalently as polynomial optimization by a randomization process. The complementarity eigenvalues can be computed sequentially. The formulated polynomial optimization can be solved by Lasserre's hierarchy of semidefinite relaxations. We show that it has finite convergence for generic tensors. Numerical experiments are presented to show the efficiency of proposed methods.

A primal-dual approach of weak-constrained data assimilation

Serge Gratton

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Data assimilation covers techniques where prediction of the state of a dynamical systems is performed using data from various origins. We consider here the optimization problem that lies in the centre of this technique, when so-called variational formulations are considered. Our main interest will be focused on case where the dynamical systems under consideration is described by *stochastic* differential equations. Such a problem is called "Weak-constrained variational Data Assimilation".

We will compare the merits of the three main approaches that are considered by the community: state, forcing, saddle-point formulations. They lead to large-scale optimization problems which must be solved iteratively. As it is usually the case in this setting, efficiency will dramatically rely on the ability to design effective parallel implementations of suitably preconditioned, convergent and variationally coherent minimization algorithms. Using these principles we derive a new variant of the saddle point algorithm in which the monotonicity of the likelihood along the iterates is enhanced.

A parametric study of the algorithms will me presented both in a sequential and idealized parallel environment on the Burgers equation and on a quasi-Geostrophic model that are considered as representative of real models occurring in Meteorology of Oceanography. We show the merits of our new saddle-point formulation and of more classical ones based on the full orthogonalization method.

On Eigenvalue Complementarity Problems

Alfredo Iusem

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Given matrices $B, C \in \mathbb{R}^{n\times n}$, the *Eigenvalue Complementarity Problem* (to be denoted EiCP(B,C)) consists of finding $(\lambda, x, w) \in \mathbb{R}\times\mathbb{R}^n\times\mathbb{R}^n$ such that $w = \lambda Bx - Cx$, $w \geq 0, x \geq 0$, $x^t w = 0$, $e^t x = 1$, with $e = (1, 1, \ldots, 1)^t \in \mathbb{R}^n$. The matrix B is assumed to be positive definite. The problem can be seen as a natural extension of the standard eigenvalue problem to cases in which the eigenvectors are required to be nonnegative, and it has many applications in engineering (e.g., contact problems). We present here results on the existence and number of solutions of EiCP, as well as numerical methods for solving it. We also consider three extensions of EiCP, for which we also present similar results. The first is the quadratic EiCP (QEiCP), where there is an additional quadratic term in λ, i.e. we have also a positive definite $A \in \mathbb{R}^n \times \mathbb{R}^n$, and we require $w = \lambda^2 Ax + \lambda Bx + Cx$, instead of $w = \lambda Bx - Cx$. The second one is the conic EiCP (CEiCP) where the nonnegativity conditions on x, w are replaced by $x \in K, w \in K^*$, where $K \subset \mathbb{R}^n$ is a closed and covex cone and K^* is its positive polar (EiCP is a particular case of CEiCP, with $K = \mathbb{R}^n_+$). The third one is the quadratic conic EiCP (QCEiCP) which puts together the two previous extensions, i.e. it requests $w = \lambda^2 Ax + \lambda Bx + Cx$, $x \in K, w \in K^*$.

SCIP-Jack: a solver for Steiner Tree problems in graphs and their relatives

Thorsten Koch

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The Steiner tree problem in graphs is a classical problem that commonly arises in practical applications as one of many variants. While often a strong relationship between different Steiner tree problem variants can be observed, solution approaches employed so far have been prevalently problem-specific. In contrast, we will present a general-purpose solver that can be used to compute optimal solutions to both the classical Steiner tree problem and many of its variants without modification. In particular, the following problem classes can be solved: Steiner Tree in Graphs (STP), Steiner Arborescence (SAP), Rectilinear Steiner Minimum Tree (RSMTP), Node-weighted Steiner Tree (NWSTP), Prize-collecting Steiner Tree (PCSTP), Rooted Prize-collecting Steiner Tree (RPCSTP), Maximum-weight Connected Subgraph (MWCSP), Degree-constrained Steiner Tree (DCSTP), Group Steiner Tree (GSTP), and Hop-constrained Directed Steiner Tree (HCDSTP). This versatility is achieved by transforming various problem variants into a general form and solving them by using a state-of-the-art MIP-framework. The result is a high-performance solver that can be employed in massively parallel environments and is capable of solving previously unsolved instances. SCIP-Jack has participated in the 11th DIMACS Implementation Challenge and been demonstrated to be the fastest solver in two categories. S-ince the Challenge tremendous progress regarding new solving routines such as transformation, preprocessing and heuristics was made, resulting in a reduction of the runtime of more than two orders of magnitude for many instances. The talk will report on the latest developments.

Symmetric Tensor Nuclear Norm

Jiawang Nie

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We discuss nuclear norms of symmetric tensors. As recently shown by Friedland and Lim, the nuclear norm of a symmetric tensor can be achieved at a symmetric decomposition. We show how to compute symmetric tensor nuclear norms, depending on the tensor order and the ground field. Lasserre relaxations are proposed for the computation. The theoretical properties of the relaxations are studied. For symmetric tensors, we can compute their nuclear norms, as well as the nuclear decomposition. The proposed methods can also be extended to nonsymmetric tensors.

First Order Methods for Solving Convex Bi-Level Optimization Problems

Shoham Sabach

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We study convex bi-level optimization problems for which the inner level consists of minimization of the sum of smooth and nonsmooth functions. The outer level aims at minimizing a smooth and strongly convex function over the optimal solutions set of the inner problem. We analyze first order methods and global sublinear rate of convergence of the method is established in terms of the inner objective function values. The talk is based on joint work with Shimrit Shtern (MIT).

Constraint Qualifications In Vector Semi-Infinite Optimization

Maxim Ivanov Todorov

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Convex vector (or multi-objective) semi-infinite optimization deals with the simultaneous minimization of finitely many convex scalar functions subject to infinitely many convex constraints. This talk provides characterizations of the weakly efficient, efficient and properly efficient points in terms of cones involving the data and Karush-Kuhn-Tucker conditions. The latter characterizations rely on different local and global constraint qualifications. The results in this presentation, published in [EJOR, 249 (2016) 32-40], generalize those obtained by several authors on linear vector semi-infinite optimization problems [EJOR, 227 (2013) 12-21].

High-Dimensional Learning with Concave Penalty

Yinyu Ye

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High dimensionality refers to the assumption that the number of fitting parameters is (much) larger than the sample size in statistical learning. Due to the emerging use of increasingly sophisticated learning models in modern data-driven applications, high dimensionality has become a looming challenge to the existing statistical theories and techniques; in solving a high-dimensional learning problem, the traditional statistical theories and tools frequently fail as a result of overfitting. This talk will introduce a recently developed regularization scheme, the (folded) concave penalty (FCP), as a remedy to the issue of high dimensionality. On FCP-based learning, there remain open questions (i) whether fast computable local solutions may ensure the statistical performance, and (ii) whether that statistical performance can be non-contingent on the specific designs of the computing procedures. My answers to both questions are affirmative. This talk will present theoretical evidence and real-world applications to showcase the efficacy of the FCP.

ADMM/DRS for Infeasible, Unbounded, and Pathological Conic Programs

Wotao Yin

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In this talk, we present a method for identifying infeasible, unbounded, and pathological conic programs based on Douglas-Rachford splitting, which is equivalent to the standard ADMM. When an optimization program is infeasible, unbounded, or pathological, the iterates of Douglas-Rachford splitting diverge. However, such divergent iterates still provide useful information, which our method uses for identification. As a first-order method, the proposed algorithm relies on simple subroutines and therefore is simple to implement and has low per-iteration cost.

This is joint work with Yanli Liu and Ernest Ryu.

Partial error bound conditions and the linear convergence rate of ADMM

Xiaoming Yuan

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In the literature, error bound conditions have been widely used for studying the linear convergence rates of various first-order algorithms and the majority of literature focuses on how to sufficiently ensure these error bound conditions, usually posing more assumptions on the model under discussion. We focus on the alternating direction method of multipliers (ADMM), and show that the known error bound conditions for studying ADMM’ s linear convergence rate, can indeed be further weakened if the error bound is studied over the specific iterative sequence generated by ADMM. A so-called partial error bound condition, which is tailored for the specific ADMM’ s iterative scheme and weaker than known error bound conditions in the literature, is thus proposed to derive the linear convergence of ADMM. We further show that this partial error bound condition theoretically justifies the difference if the two primal variables are updated in different orders in implementing ADMM, which had been empirically observed in the literature yet no theory is known so far.

Block Optimization over Riemannian Manifolds with Linear Constraints

Shuzhong Zhang

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In this talk we shall present some new results on non-convex block-optimization models over Riemannian manifolds, with binding linear constraints. We introduce some ADMM (Alternating Direction Method of Multipliers) style algorithms for a block optimization model where the objective is non-convex and each block variables are elements of some given manifolds. Moreover, there are also linear constraints linking all the variables. Such models arise naturally in tensor optimization with constraints, including approximative Tucker decomposition with constraints. Iteration complexity bounds for the iterates converging to a stationary solution are presented, together with preliminary numerical results.

Part II

Contributed Talks

Narrowing the duality gap of the extended CDT trust-region problem by second-order cone

Wenbao Ai

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In this talk, we consider the extended Celis-Dennis-Tapia (CDT) trust-region problem that has a positive duality gap. It is presented in theory that this positive duality gap can be narrowed by adding an appropriate second-order-cone (SOC) constraint. For any extended CDT problem with a positive duality gap, we have proved a necessary and sufficient condition for one SOC constraint being valid to narrow the positive duality gap. And then a sufficient condition will be showed such that the positive duality gap can be eliminated thoroughly. Some interesting instances of the extended CDT problem are showed to satisfy the sufficient condition. And several theorems presented by other researchers are just the special cases of the sufficient condition. Numerical results of some gap-existing examples coming from other papers show that their positive duality gaps are indeed eliminated by our SOC reformulation technique.

A Multilevel Gradient-Type Framework for Nonlinear Optimization

Cheng Chen

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In this talk, we propose a unified multilevel gradient-type framework for solving smooth optimization problems and composite problems. We prove that the proposed methods can reach the optimal complexity of gradient-type methods for convex problems. Preliminary numerical experiments show our multilevel method is promising.

A Method to Update Factorizations of the KKT Matrices in Active-set Methods

Liang Chen

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We describe a method for updating factorizations of KKT matrices in the active-set method to solve large-scale sparse quadratic programming. Our method is based on the LU update in the simplex method. Combining with the idea of the update factorizations to increase the dimension of KKT matrices from the Schur-complement and block-LU method, we proposed a method to deal with the sparse problem and no dense matrices should be handled. Moreover, the dimensions of KKT matrices are usually small at beginning and increases gradually. This method is potential to be applied in the QP solvers with the active-set method.

Generalized Coefficient Strengthening Cuts for Mixed Integer Programming

Weikun Chen

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Cutting plane methods are an important component in solving the mixed integer programming (MIP). By carefully studying the coefficient strengthening method, which is originally a presolving method, we are able to generalize this method to generate a family of valid inequalities called generalized coefficient strengthening (GCS) inequalities. The invariant property of the GCS inequalities is established under bound substitutions. Furthermore, we develop a separation algorithm for finding the violated GCS inequalities for a general mixed integer set. The separation algorithm is proved to have the polynomial time complexity. Extensive numerical experiments are made on standard MIP test sets, which demonstrate the usefulness of the resulting GCS separator.

Parallel Subspace Correction Method for Strongly Convex Problem

Qian Dong

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In this talk, we considered two points about the parallel subspace correction method (PSC) for the strongly smooth optimization problem, which are the inexact subproblem solution and the step size strategy. On one hand, we proved the the convergence for PSC with certain inexact subproblem solution. On the other hand, we proposed a two-stage step size strategy which can guarantee convergence. The numerical experiments showed the efficiency and suplinear speedup for PDE computation.

Parallel Approaches for Orthogonally Constrained Optimization Problems

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To construct parallel approach for solving orthogonally constrained optimization problems is usually regarded as impossible mission, due to the low scalability of orthogonalization procedure. In this talk, we propose a Jacobi type column-wise block coordinate descent method for solving a class of orthogonally constrained optimization problems, and establish the global iterate convergence to stationary point of our proposed approach. Distributed algorithms are consequently implemented. Numerical experiments illustrate that the new algorithms have brilliant performance and high scalability in solving discretized Kohn-Sham total energy minimization problems.

The Unchanged Changing World of Mathematical Publishing

Joachim Heinze

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A short overview of the history of Mathematical Publishing at Springer is giver. "Numerische Mathematik" was the first of all Springer journals over all disciplines to go online in 1994. The change of the publishing world in composing and disseminating mathematical content in electronic form. Tex and "Online Visibility" are the buzzwords here. Open Access for all mathematical content? Newinitiatives like "Overlay journals", based on the arXiv, are briefly discussed. Keep track of what has been published and cited. MathSciNet and zbMATH, the two big MathReview Journals in comparison to other initiatives, like Google Scholar/xs.glgoo.com, ResearchGate, Scopus, Web of Science. Two new initatives from SpringerNature: "Share it" and "Recommended". A new initiative from China: MathSciDoc.

Adaptive Regularized Newton Method for Riemannian Optimization

Jiang Hu

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Optimization on Riemannian manifolds widely arises in eigenvalue computation, density functional theory, Bose-Einstein condensates, low rank nearest correlation, image registration, and signal processing, etc. We propose an adaptive regularized Newton method which approximates the original objective function by the second-order Taylor expansion in Euclidean space but keeps the Riemannian manifold constraints. The regularization term in the objective function of the subproblem enables us to establish a Cauchy-point like condition as the standard trust-region method for proving global convergence. The subproblem can be solved inexactly either by first-order methods or a truncated Riemannian Newton method. In the later case, it can further take advantage of negative curvature directions. Both global convergence and superlinear local convergence are guaranteed under mild conditions. Extensive computational experiments and comparisons with other state-of-the-art methods indicate that the proposed algorithm is very promising.

Vector Transport-Free SVRG with General Retraction for Riemannian Optimization: Complexity Analysis and Practical Implementation

Bo Jiang

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In this paper, we propose a vector transport-free stochastic variance reduced gradient (SVRG) method with general retraction for empirical risk minimization over Riemannian manifold. Existing SVRG methods on manifold usually consider a specific retraction operation, and involve additional computational costs such as parallel transport or vector transport. The vector transport-free SVRG with general retraction we propose in this paper handles general retraction operations, and do not need additional computational costs mentioned above. As a result, we name our algorithm S-SVRG, where the first "S" means simple. We analyze the iteration complexity of S-SVRG for obtaining an ϵ-stationary point and its local linear convergence by assuming the Łojasiewicz inequality, which naturally holds for PCA and holds with high probability for matrix completion problem. We also incorporate the Barzilai-Borwein step size and design a very practical S-SVRG-BB method. Numerical results on PCA and matrix completion problems are reported to demonstrate the efficiency of our methods.

A fast inverse algorithm for the block tridiagonal Toeplitz matrices and its application to fast train palindromic quadratic eigenvalue problems

Shengguo Li

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In this talk we present a fast algorithm for computing the inverse of a block tridiagonal Toeplitz matrix, which can be used to solve the palindromic quadratic eigenvalue problems arising from vibration of fast trains. The palindromic quadratic eigenvalue problems can be solved by using the doubling algorithms [Guo and Lin SIMAX, 2010, Lu, Yuan, and Li, NLAA, 2014]. It requires to compute three blocks of the inverse of a block tridiagonal Toeplitz matrix. Comparing with the algorithms in previous works, our algorithm can be ten times faster when the matrices are large.

Electronic structure calculation using semidefinite programs

Yongfeng Li

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Electronic structure calculation can be modelled by a variational approach where the two-body reduced density matrix (RDM) is the unknown variable. It can lead to an extremely large-scale semidefinite programming (SDP) problem. This talk will present a practically efficient second-order type method.

A Sparse Completely Positive Relaxation of the Modularity Maximization for Community Detection

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Many real networks have community structures. The graph will display some tightly dense connections inside the communities (a subset of nodes) and less dense between the communities. To find the underlying community structure in a network is important for a number of reasons. For example, it allows us to treat each community as a meta-node thus simplifies the network study. To detect the community structure, we propose a sparse and low-rank completely positive relaxation of the modularity maximization problem, then develop an efficient row-by-row (RBR) type block coordinate descent (BCD) algorithm to solve the relaxation and prove an $\mathcal{O}(1/\sqrt{T})$ convergence rate to a stationary point. A fast rounding scheme is proposed to retrieve the community structure from the solution. Non-asymptotic high probability bounds on the misclassification rate are established to justify our approach. We further propose an asynchronous parallel RBR algorithm to speed up the convergence. Extensive numerical experiments on both synthetic and real world networks show that our method enjoys advantages in both clustering accuracy and numerical efficiency. In particular, our method is quite competitive to the state-of-the-art methods on sparse networks with over 50 million nodes.

Calculus of Convex Polyhedra and Polyhedral Convex Functions

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Given two convex polyhedra, we intend to compute, for instance, their Minkowski sum, intersection or convex hull of the union. Another basic problem is to compute the polar of a polyhedron. The talk surveys practically relevant methods for such operations. One method is based on a recent result saying that multiple objective linear programming is equivalent to the projection of a convex polyhedron into a lower dimensional space. We show how a multiple objection linear programming solver can be utilized for polyhedral calculus. Finally we discuss a method to represent polyhedral convex functions in a very general way. Given two polyhedral convex functions, we provide a practically relevant method to compute, for instance, their infimal convolution, pointwise maximum or lower convex envelope. We compute a representation of the conjugate of a polyhedral convex function. The talk also discusses modelling techniques for optimization problems involving polyhedral convex functions. Finally, the relevance of the presented methods for certain classes of global optimization problems is discussed.

High-performance technique for satellite range scheduling

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As the number of daily satellite service requests increases, the satellite range scheduling problem becomes more intractable during the ground station operations management. The NP-complete problem involves scheduling satellite requests to ground station antennas within their time windows so that the profit from the scheduled requests is maximized. This paper analyzes various conflicts between satellite requests and then develops a conflict-resolution technique. The technique first builds an elite initial schedule using a prescheduling strategy and then improves the initial schedule using a rescheduling strategy in a subspace of feasible solutions. The main highlight of the technique is its dual functions of quickly generating a high-quality solution and providing a good bound. As shown in the experimental results from the actual data and more difficult random instances, the proposed technique is significantly better than the best-known heuristic.

A globalized semismooth Newton method for generalized variational inequality problems

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In this talk, we present a globalized semismooth Newton method for solving generalized variational inequality problems (GVIP). The considered class of problems comprises a variety of variational problems, including mixed variational inequalities, classical variational inequalities, nonlinear saddle point problems or optimality conditions of convex composite problems. Our approach is based on a reformulation of the variational inequality as a proximal-type fixed point equation. In many important situations, the proximity operator can be shown to be semismooth and the semismooth Newton method can be applied to solve the resulting nonsmooth equation. The algorithmic framework we investigate combines the semismooth Newton method with a globally convergent descent method that is based on a generalized D-gap function for the GVIP. The acceptance of the Newton steps is controlled by a filter mechanism. We present both global and local convergence results and conclude with numerical examples demonstrating the efficiency of the proposed method.

Analysis of a new dimension-wise splitting iteration with selective relaxation for saddle point problems

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In this talk, we will discuss a new Dimension-wise Splitting with Selective Relaxation (DSSR) method for structured system of linear equations arising from the discretization of the incompressible Navier-Stokes equations. On the selection of the relaxation parameter, Fourier analysis will be adopted to determine the optimal parameter that leads to the best performance of the iterative method for the Stokes and the steady Oseen equations. We also explore numerically the influence of boundary conditions on the optimal choice of the parameter. The use of inner and outer iterations will also be evaluated on a lid driven cavity flow.

This is a joint work with Prof. Martin J. Gander (University of Geneva) and Prof. Yingxiang Xu (Northeast Normal University).

Approximation of Convex Bodies by Multiple Objective Optimization and an Application in Reachable Sets

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In this paper, we focus on approximating convex compact bodies. For a convex body described as the feasible set in objective space of a multiple objective programme, we show that finding it is equivalent to finding the non-dominated set of a multiple objective programme. This equivalence implies that convex bodies can be approximated using multiple objective optimization algorithms. Therefore we propose a revised outer approximation algorithm for convex multiple objective programming problems to approximate convex bodies. Finally, we apply the algorithm to solve reachable sets of control systems and use numerical examples to show the effectiveness of the algorithm.

An Alternating Minimization Method for Robust Principal Component Analysis

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We focus on solving robust principal component analysis (RPCA) arising from various applications such as information theory, statistics, engineering, and etc. We adopt a model to minimize the sum of observation error and sparsity measurement subject to the rank constraint. To solve this problem, we propose a two-step alternating minimization method. In one step, a symmetric low rank product minimization, which essentially is partial singular value decomposition, can be efficiently solved to moderate accuracy. Meanwhile the second step has closed-form solution. The new proposed approach is almost parameter-free, and its global convergence to a strict local minimizer can be derived under almost no assumption. We compare the proposed approach with some existing solvers and the numerical experiments demonstrate the outstanding performance of our new approach in solving a bunch of synthetic and real RPCA test problems. Especially, we discover the great potential of the proposed approach in solving problem with large size to moderate accuracy.

A new gradient method improving Yuan's stepsize

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It is popular to solve large scale problems by gradient methods. Based on the idea of coordination transformation, we proposed a new stepsize update strategy for the gradient method, which is the extension of Yuan's stepsize from 2-dimension to 3-dimension. For 3-dimensional convex quadratic function minimization problems, it guarantees to find the optimal solution in 5 iterations. We also modified the strategy to improve the performance. We proved that, for 3-dimensional convex quadratic function minimization problems, the new modified gradient method terminates in finite iterations; for general dimensional problems, it converges R-linearly.

Discrete Approximation of Two-Stage Stochastic and Distributionally Robust Linear Complementarity Problems

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In this paper, we propose a discretization scheme for the two-stage stochastic lin- ear complementarity problem (SLCP) where the underlying random data are continuously distributed. Under some moderate conditions, we derive qualitative and quantitative convergence for the solutions obtained from solving the discretized two-stage SLCP. We explain how the discretized two-stage SLCP may be solved by the well-known progressive hedging method. Moreover, we extend the discussion by considering a two-stage distributionally robust SLCP (DRSLCP) with moment constraints and proposing a discretization scheme for the DRSLCP. As an application, we show how the SLCP and DRSLCP models can be used to study equilibrium arising from two-stage duopoly game where each player plans to set up its optimal capacity at present with anticipated competition for production in future. the paper is a joint work with Professor Xiaojun Chen and Professor Huifu Xu.

Searching for Maxima in Multy-extreme Function

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An expansion in series of (virtual) Hermite polynomials of f(x) symmetrized around objective point "u" gives coefficients represented as nonlinear functions of "u", i.e."Co(u)". These "Co(u)" indicate zones of highest maxima comprising global one. The searching for these maxima starts from analysis of entire region of definition of f(x) to localization of zone of unimodal character f(x) that is determined by Co(u). A multi-dimensional analogue of Co(u) ("u" is vector) has been successfully implemented in some tasks. The development of this direction required a creation of "Special Mathematical Technology" (a variety of concomitant non-linear tasks including even related to local optimization) and several years. This method has been applied in a trajectory recognition problem and can be generally used in Data Science as well.

A Low Rank Matrix Decomposition Method for Single-Cell Data Analysis

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Recent advances in single cell technology enable dissecting cell populations at individual cell level. One of the key challenges in analyzing the single cell gene expression data is to extract the salient features underlying the dynamics process of cell state transitions. Here we present an optimization approach to classify cell states and branching processes. More specifically, a structured cell-to-cell similarity matrix is computed through a low rank optimization model, and the resulted similarity matrix is then used to estimate different cell states by non-negative matrix factorization. The temporal order of cells is evaluated by the non-negative rank one approximation of the cell-to-cell similarity matrix, an approach conserving the overall data structure. Transition paths among different states are inferred via the minimum spanning tree of the weighted cluster-to-cluster graph. The proposed method is applied to several published single-cell datasets and the direct simulation results suggest the efficiency and robustness of the method in determining cell types, pseudo-time ordering, and lineage trees.

Proximal Stochastic Quasi-Newton methods for Constrained Nonconvex Composition Optimization

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In this paper, we consider second order methods for solving a generic nonconvex composition problem arising in machine learning. Stochastic variance reduction gradient(SVRG) method is proved to be prominent both convex and nonconvex problems. Here, we propose a new and simple demonstration framework to show non-asympotic convergence of SVRG to stational points with $O(\frac{n^{\frac{2}{3}}}{\epsilon})$ complexity for nonconvex and constrained optimization and extend the results to second order methods as long as the approximation of hessian matrix B is symmetric positive definite and uniformly bounded. We also propose a symmetric rank one(SR1) type method to update hessian matrix B to satisfy the above condition we demand. Besides, we extend the proximal Polyak-Łojasiewicz(PL) inequality to the constrained setting and prove that under this condition, the second order algorithms achieve a linear convergence rate for the constrained composition problem.

An infeasible primal-dual interior point Method for computing the analytic center of an ill-conditioned polytope

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In this talk, we will discuss how to compute the analytic center of the polytope $P = \{x \in R^n \mid Ax = b, x \geq 0\}$, where the matrix A is ill-conditioned. We will first derive some regularization results for the ill-conditioned problem. Then based on the interior point method for linear programming, we will propose an infeasible primal-dual interior point algorithm for effectively computing of the analytic center of the ill-conditioned polytope. The convergence of the iteration sequences will be given. Finally, some numerical results will be presented to show the effectiveness of the new method and conclusions will be given.

Vector Linear Programming by Polyhedral Projection Problems

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Consider a vector-valued function $f : \mathbb{R}^d \to \mathbb{R}^q$ and the feasible set $X \subseteq \mathbb{R}^d$. A *Vector Optimisation Problem* consists in finding

$$\min f(x) \text{ subject to } x \in X. \tag{VOP}$$

Embedding (VOP) into a set-valued framework has proven to be a very fruitful approach, c.f. [1]. Especially, algorithms for solving Vector Linear Programmes (X is a polyhedral convex set and f is linear) have been developed and implemented based on this approach [2].

We consider another type of problem: Given a closed, convex polyhedron $S \subseteq \mathbb{R}^{d+q}$, one tries to

$$\text{compute } P = \left\{ y \in \mathbb{R}^q \mid \exists x \in \mathbb{R}^d : \left(\begin{smallmatrix} x \\ y \end{smallmatrix}\right) \in S \right\}. \tag{PP}$$

Here, to "compute" means to obtain a description of the polyhedron P in terms of vertices/directions or in terms of intersecting half spaces. Problem (PP) is called *Polyhedral Projection Problem*. At first glance, (PP) is not related to optimisation. However, it has been shown that Vector Linear Programmes are equivalent to Polyhedral Projection Problems, see [3]. Hence for any application which can be expressed in terms of Vector Linear Programming a description in terms of (PP) is also possible. Moreover, this In many cases, a representation may be simpler or "more natural" than the conversion to a Vector Linear Programme.

In this talk, a solution concept for (PP) will be introduced. Algorithms to solve (PP) according to this solution concept will be presented. Furthermore, polarity between convex polyhedra will be used to establish a duality theory for (PP).

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[3] A. Löhne and B. Weissing, *Equivalence between polyhedral projection, multiple objective linear programming and vector linear programming*, Math Meth Oper Res (2016). doi:10.1007/s00186-016-0554-0

An efficient Peaceman-Rachford splitting method for constrained TGV-shearlet based MRI reconstruction

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In this paper, we propose a constrained total generalized variation and shearlet transform based model for magnetic resonance imaging reconstruction, which is usually more undemanding and practical to identify appropriate tradeoffs than its unconstrained counterpart. The proposed model can be facilely and efficiently solved by the strictly contractive Peaceman-Rachford splitting method, which generally outperforms some state-of-the-art algorithms when solving separable convex programming. Numerical simulations demonstrate that the sharp edges and grainy details in magnetic resonance images can be well reconstructed from the undersampling data.

Convergence Rate of Gradient Descent Method for Multi-Objective Optimization

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Under some standard assumptions, we prove that the gradient descent method for multi-objective optimization problem enjoys the same convergence rate as that for scalar optimization. Particularly, when the objective functions are convex, the gradient method with constant step-size converges sublinearly. In addition, the linear convergence of the method for strongly convex objective functions is established. Those convergence results are extended to the method with Armijo line search.

The Rate of Convergence of the Augmented Lagrangian Method for a Nonlinear Semidefinite Nuclear Norm Composite Optimization Problem

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We analyze the rate of local convergence of the augmented Lagrangian method for a nonlinear semidefinite nuclear norm composite optimization problem. Without requiring strict complementarity, we prove that, under the constraint nondegeneracy condition and the strong second order sufficient condition, the rate of convergence is linear and the ratio constant is proportional to $1/c$, where c is the penalty parameter that exceeds a threshold $\overline{c} > 0$. The analysis is based on variational analysis about the projection operator onto the cone of positively semidefinite symmetric matrices and the proximal mapping of the nuclear norm.

Limited memory algorithms with cubic regularization

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We consider a model with a cubic regularization where the cubic term is determined by the eigendecomposition of a limited memory Hessian approximation. Although the model function may potentially have an exponential number of distinct local minima, its global minimizer can be obtained in closed form. The required eigenvalue decomposition is produced using an efficient approach introduced recently for limited memory Hessian approximations. Convergence results are presented for a standard cubic regularization framework. The efficiency of our algorithms is demonstrated by results of numerical experiments.

Tensor Maximal Correlation Problems

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In this talk, we study the tensor maximal correlation problem, which aims at optimizing correlations between sets of variables in many statistical applications. We construct a hierarchy of semidefinite relaxations for solving it, and prove that the global maximizers of the problem can be detected by solving a finite number of such semidefinite relaxations. Numerical experiments show the efficiency of the proposed method.

Anomaly detection in dynamic attributed graphs

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Dynamic attributed graphs represent time-varying social network applications where both users' profile data and social relationships change with time. Although there have been a line of approaches proposed for anomaly detection from graph data, how to extend these approaches for analyzing dynamic attributed graphs have not yet been explored. In this work, we present a new model for detecting anomalous nodes from dynamic attributed graphs. Specifically, we use a data-driven method to infer the dynamic network structure, based on which a new attributed graph anomaly detection model is proposed by embedding the dynamic network structure, the graph structure data, and the node attribute data for isolating anomalous nodes.

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The organizing committee wishes you a pleasant stay in Yinchuan!

The Park of Customs and Culture in the Homeland of Chinese Hui People