The 12th International Conference on Numerical Optimization and Numerical Linear Algebra

April 15-18, 2019

Shangrao, Jiangxi, China

http://lsec.cc.ac.cn/~icnonla19

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Information for Participants

Conference Hotel and Conference Venue

Hotel: Muxin City Hotel, Shangrao

上饶沐鑫城市酒店

Address: 351, Fenghuang Middle Ave, Xinzhou Qu, Shangrao Shi, Jiangxi

江西省上饶市信州区凤凰中大道351号

Venue: April 15:

Lecture Hall at 5th floor, Library in Shangrao Normal University

上饶师范学院图书馆五楼报告厅

April 16 - 17:

Jingxin Conference Hall at 16th floor, Muxin City Hotel

上饶沐鑫城市酒店16楼景鑫会议中心

Arrival

By air: the distance between Shangrao Airport and the conference hotel is about 11 km. It will cost you about 40 RMB (6 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 8 km from Shangrao railway station to the conference hotel. The taxi fare is about 25 RMB (4 USD c.a.).

On-site Registration

On-site registration will take place at the **lobby of Muxin City Hotel, Shangrao** on **April 14** from **11:00** to **21:00**. You can also register at any ohter time during the conference, but please contact Ms. Ying Liu or Ms. Xiaoyu Wang in advance.

Currency

Chinese currency is RMB. The current rate is about 6.71 RMB for 1 US dollar. The exchange of foreign currency can be done at the airport or the banks in Shangrao. 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. Besides, the Wi-Fi in Muxin City Hotel is free and can be connected without any password.

Contact Information

If you need any help, please feel free to contact

- Ms. Ying Liu: +86-138-1080-6086
- Ms. Xiaoyu Wang: +86-152-0129-0219

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The 12th International Conference on Numerical Optimization and Numerical Linear Algebra

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Conference Schedule

April 15, Monday

09:00-09:40 Opening Ceremony

- **09:00-09:20 Welcome Address**
- **09:20-09:40 Group Photo**

09:40-10:20 Invited Talks V1
Chair: Ya-xiang Yuan

- **09:40-10:20 Nick Higham**, Squeezing a Matrix Into Half Precision, with an Application to Solving Linear Systems

10:20-10:40 Coffee Break

10:40-12:00 Invited Talks V2
Chair: Yuhong Dai

- **10:40-11:20 Tom Luo**, A Proximal Alternating Direction Method of Multiplier for Linearly Constrained Nonconvex Minimization
- **11:20-12:00 Hans D. Mittelmann**, Benchmarking Optimization Software-a (Hi)Story

12:00-14:00 Lunch

14:00-15:20 Contributed Talks C1

Chair: Tom Luo

14:00-14:20 **Liwei Zhang**, The Rate of Convergence of Proximal Method of Multipliers for Nonlinear Semidefinite Programming

14:20-14:40 **Xinwei Liu**, A Primal-Dual Interior-Point Relaxation Method for Nonlinear Programming

14:40-15:00 **Xinlong Luo**, Several Key Mathematical Problems Arising from Simultaneous Localization and Mapping Based on Inertial Navigation and Robotic Vision

15:00-15:20 **Agnieszka Wiszniewska-Matyszkiel**, When Inaccuracies in Value Functions do not Propagate on Optima and Equilibria

15:20-15:40 Coffee Break

15:40-16:40 Contributed Talks C2

Chair: Hans D. Mittelmann

15:40-16:00 **Hongxia Wang**, Phase Retrieval with Background Information

16:00-16:20 **Tao Wang**, On a TRUST-TECH Based Methodology for Integer Programming and Its Related Theory

16:20-16:40 **Qingna Li**, A Semismooth Newton Method for Support Vector Classification and Regression

16:40-18:00 Contributed Talks C3

Chair: Nick Higham

16:40-17:00 **Yanfei Jing**, Recent Development on BCG-like Variants with Reduction of Loss of Orthogonality

17:00-17:20 **Cong Sun**, New Gradient Method with Adaptive Stepsize Update Strategy

17:20-17:40 **Wen Huang**, Riemannian Optimization for Computing Low-rank Solutions of Lyapunov Equations with a New Preconditioner

17:40-18:00 **Tingting Wu**, Sparsity Reconstruction using Nonconvex TGpV-Shearlet Regularization and Constrained Projection

18:00 Dinner

April 16, Tuesday

09:00-10:20 Invited Talks V3

Chair: Xiaojun Chen

09:00-09:40 **Yin Zhang**, Selective Minimization: How Gauss Globalizes Newton

09:40-10:20 **Yuhong Dai**, Complexity of Computing an Arbitrary Lifted Cover Inequality

10:20-10:40 Coffee Break

10:40-12:00 Invited Talks V4

Chair: Yin Zhang

10:40-11:20 **Defeng Sun**, A Majorized Proximal Point Dual Newton Algorithm for Nonconvex Statistical Optimization Problems

11:20-12:00 **Kim Chuan Toh**, SDPNAL+: A Matlab Software Package for Large Scale Bound Constrained Semidefinite Programming with a Basic User-Friendly Interface

12:00-14:00 Lunch

14:00-15:20 Contributed Talks C4

Chair: Kim Chuan Toh

14:00-14:20 **Congpei An**, Regularized Weighted Discrete Least Squares Approximation by Orthogonal Polynomials

14:20-14:40 **Xiangfeng Wang**, A Fast Proximal Point Method for Computing Exact Wasserstein Distance

14:40-15:00 **Anwa Zhou**, Completely Positive Tensors in Complex Field

15:00-15:20 **Xudong Li**, On the Equivalence of Inexact Proximal ALM and ADMM for a Class of Convex Composite Programming

15:20-15:40 Coffee Break

15:40-16:40 Contributed Talks C5

Chair: Liwei Zhang

15:40-16:00 **Zhe Sun**, A Penalty Method for Solving a Class of Structured Nonsmooth DC Constrained DC Programs

16:00-16:20 **Arshak Minasyan**, Robust Estimation through Huber Function

16:20-16:40 **Tea Shavadze**, Necessary Conditions of Optimality for the Nonlinear Optimal Control Problem with Delays and the Discontinuous Initial Condition

16:40-18:00 Contributed Talks C6

Chair: Yunbin Zhao

16:40-17:00 **Xiaoyu Wang**, Stochastic Trust Region Methods with Trust Region Radius Depending on Probabilistic Models

17:00-17:20 **Liang Chen**, Exact Separation Algorithm for Unsplittable Capacitated Network Design Flow Arc-set Polyhedron

17:20-17:40 **Xiaokai Chang**, Proximal Extrapolated Gradient Methods with Larger Step Size for Monotone Variational Inequalities

17:40-18:00 **Xueying Zhao**, Nonconvex Correction Approach for Robust Tensor Completion from Grossly Sparse Observations

18:00 Dinner

April 17, Wednesday

09:00-10:20 Invited Talks V5

Chair: Defeng Sun

09:00-09:40 Tanka Nath Dhamala, Network Reconfiguration for the Minimization of Evacuation Time

09:40-10:20 Yimin Wei, Randomized Algorithms for the Low Multilinear Rank Approximations of Tensors

10:20-10:40 Coffee Break

10:40-12:00 Contributed Talks C7

Chair: Tanka Nath Dhamala

10:40-11:00 Zaikun Zhang, Trust-region Method based on Inaccurate First-order Information

11:00-11:20 Nachuan Xiao, Variable Splitting Method for Matrix Optimization Problem with Symmetric Structure

11:20-11:40 Yuchen Wu, An Incremental Gauss-Newton Method for L2 Regularized Finite Sum Problem

11:40-12:00 Yadan Chen, Alternating Direction Method of Multipliers to Solve Two Continuous Models for Graph-based Clustering

12:00-14:00 Lunch

14:00-15:20 Invited Talks V6

Chair: Yimin Wei

14:00-14:40 Yunbin Zhao, Optimal Thresholding Algorithms for Compressed Sensing Problems

14:40-15:20 Zaiwen Wen, Optimization Algorithms for Data Analysis

15:20-15:40 Coffee Break

15:40-16:20 Contributed Talks C8

Chair: Zaiwen Wen

15:40-16:00 Jiang Hu, Structured Quasi-Newton Methods for Optimization with Orthogonality Constraints

16:00-16:20 Yongfeng Li, Low-rank Matrix Optimization Using Subspace Extraction

16:20-16:40	**Closing Ceremony**
18:00	**Dinner**

April 18, Thursday

Free Discussion

Abstracts

Part I

Invited Talks

Complexity of Computing an Arbitrary Lifted Cover Inequality

Yuhong Dai

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The well-known lifted cover inequality is widely employed in solving mixed integer programs. However, it is still an open question whether an arbitrary project lifted cover inequality can be computed in polynomial time for a given minimal cover (Gu, Nemhauser, and Savelsbergh, INFORMS J. Comput., 26: 117123, 1999). We show that this problem is NP-hard, thus giving a negative answer to the question. This is a joint work with Wei-Kun Chen.

Network Reconfiguration for the Minimization of Evacuation Time

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The field of evacuation planning is a very fertile research area of mathematical sciences and operational research in these days. A large number of scientists from the field of mathematical sciences, operational research, management science, engineering and even from social sciences are involved in solving the challenging issues raised form different types of natural and man-made disasters. Although these phenomena are unavoidable from nature, an efficient evacuation plan can save a huge amount of property loss and save a significant number of people from a quite panic situation. Mathematically, a disastrous zone is modeled as an evacuation region and evacuation process progresses dynamically as required using many sorts of mathematical tools, like dynamical fluid equations, variational inequalities, optimal control setups, simulation modelings, mathematical programming and dynamic network flow models. We concentrate on the last one, known as network ow approach, which seeks to model the problem in a discrete network over time. These models are very compromised from the point of computational efficiency at the cost of qualitative solutions. However, a lot of diversities on these models do exist in literature because of the time dependency and ow dependency on the attributes attached at the network topology. Unfortunately, a large number of general problems be- long to the class of $\mathcal{NP}$-hard problems. Still, many particular problems are solvable with polynomial time complexity.

Our main focus of this presentation is to expose the difficulty level of the quickest ow problems and explore many efficient algorithms obtained recently and also in the past. We concentrate on the contra ow reconfiguration of the network topology cooperated with the problem of facility locations in order to minimize the evacuation time. This approach also seeks to minimize the clearance time without reversing the arcs unnecessarily. The quickest contra ow and the quickest contra-transshipment problems are illustrated with efficient algorithms. These current results prove that the evacuation time can be drastically reduced with the partial lane reversals on evacuation network at emergency.

Squeezing a Matrix Into Half Precision, with an Application to Solving Linear Systems

Nick Higham

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We consider solving a linear system $Ax = b$, with double precision A and b, by the use of an LU factorization computed in half precision and mixed-precision GMRES-based iterative refinement (GMRES-IR). For many matrices arising in practice, rounding A to half precision results in underflow and overflow. We develop an algorithm for converting a matrix from double precision to half precision that attempts to avoid these problems. It first applies two-sided diagonal scaling in order to equilibrate the matrix then multiplies by a scalar to bring the largest element within a factor $\theta \leq 1$ of the overflow level, and finally rounds to half precision. The second step ensures that full use is made of the limited range of half precision arithmetic, and θ must be chosen to allow sufficient headroom for subsequent computations. Previous implementations of GMRES-IR have used a crude conversion to half precision that our experiments show can cause slow convergence of GMRES-IR for badly scaled matrices or failure to converge at all. We show that the new conversion algorithm leads to faster convergence of GMRES-IR for badly scaled matrices and thereby allows a much wider class of problems to be solved.

This is joint work with Srikara Pranesh and Mawussi Zounon.

A Proximal Alternating Direction Method of Multiplier for Linearly Constrained Nonconvex Minimization

Tom Luo

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Consider the minimization of a nonconvex differentiable function over a polyhedron. A popular primal-dual first-order method for this problem is to perform a gradient projection iteration for the augmented Lagrangian function and then update the dual multiplier vector using the constraint residual. However, numerical examples show that this approach can exhibit "oscillation" and may not converge. In this paper, we propose a proximal alternating direction method of multipliers for the multi-block version of this problem. A distinctive feature of this method is the introduction of a "smoothed" (i.e., exponentially weighted) sequence of primal iterates, and the inclusion, at each iteration, to the augmented Lagrangian function a quadratic proximal term centered at the current smoothed primal iterate. The resulting proximal augmented Lagrangian function is inexactly minimized (via a gradient projection step) at each iteration while the dual multiplier vector is updated using the residual of the linear constraints. When the primal and dual stepsizes are chosen sufficiently small, we show that suitable "smoothing" can stabilize the "oscillation", and the iterates of the new proximal ADMM algorithm converge to a stationary point under some mild regularity conditions. Furthermore, when the objective function is quadratic, we establish the linear convergence of the algorithm. Our proof is based on a new potential function and a novel use of error bounds. Extensions to the min-max problem will also be presented.

This is a joint work with Jiawei Zhang.

Benchmarking Optimization Software- a (Hi)Story

Hans D. Mittelmann

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For more then twenty years we have been providing information on optimization software. This includes in particular performance evaluations over a wide range of problems and for both commercial and non-commercial software. Of the commercial products mainly CPLEX, Gurobi, and XPRESS are benchmarked on our own problem selections or instance libraries when available. This effort informs the public about the state-of-the-art and pushes the developers to improve their codes. While this went smoothly for many years, in late 2018 an event changed the situation substantially. The development will be chronicled and in addition to the presented history, a story will be told about the recent episode and how it affects the future.

A Majorized Proximal Point Dual Newton Algorithm for Nonconvex Statistical Optimization Problems

Defeng Sun

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In this talk, we consider high-dimensional nonconvex statistical optimization problems such as the regularized square-root Lasso problem, where in the objective the loss terms are possibly nonsmooth or non-Lipschitian and the regularization terms are the difference of convex functions. We shall introduce a majorized proximal point dual Newton algorithm (mPPDNA) for solving these large scale problems. Our key idea for making the proposed mPPDNA to be efficient is to develop a dual based semismooth Newton method of low computational complexities for solving the corresponding subproblems. By using the Kurdyka-Łojasiewicz property exhibited in the underlining problems, we prove that the mPPDNA algorithm converges to a d-stationarity point. We also analyze the oracle property of the initial problems used in our algorithm. Extensive numerical experiments are presented to demonstrate the high efficiency of the proposed algorithm.

SDPNAL+: A Matlab Software Package for Large Scale Bound Constrained Semidefinite Programming with a Basic User-Friendly Interface

Kim Chuan Toh

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SDPNAL+ is a Matlab software package that implements an augmented Lagrangian based method to solve large scale semidefinite programming problems with bound constraints. The implementation was initially based on a majorized semismooth Newton-CG augmented Lagrangian method, here we designed it within an inexact symmetric Gauss-Seidel based semi-proximal ADMM/ALM (alternating direction method of multipliers/augmented Lagrangian method) Framework for the purpose of deriving simpler stopping conditions and closing the gap between the practical implementation of the algorithm and the theoretical algorithm. The basic code is written in Matlab, but some subroutines in C language are incorporated via Mex files. We also design a convenient interface for users to input their SDP models into the solver. Numerous problems arising from combinatorial optimization and binary integer quadratic programming problems have been tested to evaluate the performance of the solver. Extensive numerical experiments conducted in [Yang, Sun, and Toh, Mathematical Programming Computation, 7 (2015), pp. 331–366] show that the proposed method is quite efficient and robust, in that it is able to solve 98.9% of the 745 test instances of SDP problems arising from various applications to the accuracy of 1e-6 in the relative KKT residual. [Based on joint work with Defeng Sun, Yancheng Yuan and Xinyuan Zhao]

Randomized Algorithms for the Low Multilinear Rank Approximations of Tensors

Yimin Wei

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In this talk, we develop efficient methods for the computation of low multilinear rank approximations of tensors based on randomized algorithms. Combining the random projection with the singular value decomposition, the rank revealing QR decomposition and the rank revealing LU factorization, respectively, we obtain three randomized algorithms for computing the low multilinear rank approximations. Based on the singular values of sub-Gaussian matrices, we derive the error bounds for each algorithm with probability. We illustrate the proposed algorithms via several numerical examples. (Joint with Maolin Che and Hong Yan)

Optimization Algorithms For Data Analysis

Zaiwen Wen

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Optimization models are ubiquitous in data analysis. In this talk, we will introduce fast inertial relaxation methods for large scale machine learning problems, efficient subspace extractions for matrix optimization problems with spectral or low-rank structures, and a trust-region type method for nonsmooth composite convex programs where the objective function of our trust region subproblem is always smooth and quadratic.

Selective Minimization: How Gauss Globalizes Newton

Yin Zhang

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We revisit some simple and rarely noticed results published 20 years ago. These results characterize local convergence (attraction) or non-convergence (repulsion) behavior for the standard iterative framework in unconstrained minimization. Besides providing interpretations to known properties from different angles, we emphasize the property of selective minimization that can be potentially useful in modern applications of global optimization. In particular, we show that on certain nonconvex least squares problems, the Gauss-Newton method possesses a desirable behavior of only seeking global (or good local) minima, while the Newton method is blindly attracted to all kinds of stationary points. (Joint work with Richard Tapia and Leticia Velazquez)

Optimal Thresholding Algorithms for Compressed Sensing Problems

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The existing hard thresholding methods may cause a dramatic increase and numerical oscillation of the residual. This inherit drawback renders the algorithms unstable and generally inefficient for solving practical compressed sensing problems. How to develop an efficient thresholding technique becomes a fundamental question in this area. In this presentation, the notion of optimal k-thresholding will be introduced and a new thresholding technique going beyond the existing frame will be discussed. This leads to a natural design principle for efficient thresholding algorithms. It turns out that the theoretical performance for the proposed optimal thresholding algorithms is guaranteed under an improved RIP bound. The numerical experiments demonstrate that the traditional hard-thresholding algorithms have been significantly transcended by our proposed algorithms which also outperform the classic l1-minimization method in sparse signal recovery.

Part II

Contributed Talks

Regularized Weighted Discrete Least Squares Approximation by Orthogonal Polynomials

Congpei An

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We consider polynomial approximation over the interval $[-1, 1]$ by a class of regularized weighted discrete least squares methods with ℓ_2- regularization and ℓ_1- regularization terms, respectively. It is merited to choose classical orthogonal polynomials as basis sets of polynomial space with degree at most L. As node sets we use zeros of orthogonal polynomials such as Chebyshev points of the first kind, Legendre points. The number of nodes, say $N + 1$, is chosen to ensure $L \leq 2N + 1$. With the aid of Gauss quadrature, we obtain approximation polynomials of degree L in closed form without solving linear algebra or optimization problem. It can be shown that there is an extention of Wang-Xiang formula for classical polynomial interpolation.

We then study the approximation quality of ℓ_2- regularization approximation polynomial, especially on the Lebesgue constant. Moreover, the sparsity of ℓ_1- regularization approximation polynomial is presented. Finally, we give numerical examples to illustrate these theoretical results and show that well-chosen regularization parameter can provide good performance approximation, with or without contaminated data.

Proximal Extrapolated Gradient Methods with Larger Step Size for Monotone Variational Inequalities

Xiaokai Chang

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This talk is devoted to an efficient proximal-gradient-based (PG) method for solving variational inequality problems with monotone and Lipschitz-continuous mapping in Hilbert space. In the existing PG methods, the step size requires the knowledge of the Lipschitz constant of the mapping, linesearch procedure or is generated according to the progress of the algorithms but converges to a smaller positive number (or even zero) for guaranteeing convergence, which is not practical. To overcome these drawbacks, we present a proximal extrapolated gradient algorithm with larger step size, and extend the acceptable range of parameters to ensure the convergence. Due to the extension of parameter’s range, only the subsequence weakly converging to a solution of problem can be established theoretically to exist, but such subsequences can be extracted easily in our algorithm by comparing two values per iteration, without any additional calculation. The proposed method is as simple as the proximal gradient method, requiring only one proximal operator and one value of the mapping per iteration. We establish the ergodic convergence rate for general cases and R-linear convergence rate for a special case under the strong monotonicity assumption. The numerical experiments illustrate the improvements in efficiency from the larger step size.

Exact Separation Algorithm for Unsplittable Capacitated Network Design Flow Arc-set Polyhedron

Liang Chen

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In this work, we are concerned with the flow arc-set polyhedron of the unsplittable capacitated network design problem. By analyzing the property of the nontrivial facet of the flow arc-set polyhedron, we design an exact algorithm to solve the separation problem over it such that the generated inequality always defines a facet. In order to make this approach practical, several techniques are proposed to speed up the exact separation algorithm. Finally, a comprehensive computational study is presented for the unsplittable capacitated network design problem, which demonstrates the effectiveness of the proposed algorithm.

Alternating Direction Method of Multipliers to Solve Two Continuous Models for Graph-based Clustering

Yadan Chen

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Clustering is an important topic in data science. The popular approaches including K-means algorithm and nonnegative matrix factorization (NMF) directly use data points as input and consider problems in Euclidean space. However, when data points are sampled from complex structures such as a ring structure, it is necessary to describe non-Euclidean distance between data points in the form of a graph. In this paper, we propose a new approach which considers Gaussian kernel based on graph construction. Moreover, the final cluster labels can be directly obtained without post-processing, whereas NMF still needs k-means post-processing. The experimental results on real data sets have shown that the proposed approach achieves better clustering results in terms of accuracy and mutual information.

Structured Quasi-Newton Methods for Optimization with Orthogonality Constraints

Jiang Hu

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In this paper, we study structured quasi-Newton methods for optimization problems with orthogonality constraints. Note that the Riemannian Hessian of the objective function requires both the Euclidean Hessian and the Euclidean gradient. In particular, we are interested in applications that the Euclidean Hessian itself consists of a computational cheap part and a significantly expensive part. Our basic idea is to keep these parts of lower computational costs but substitute those parts of higher computational costs by the limited-memory quasi-Newton update. More specifically, the part related to the Euclidean gradient and the cheaper parts in the Euclidean Hessian are preserved. The initial quasi-Newton matrix is further constructed from a limited-memory Nyström approximation to the expensive part. Consequently, our subproblems approximate the original objective function in the Euclidean space and preserve the orthogonality constraints without performing the so-called vector transports. When the subproblems are solved to sufficient accuracy, both global and local q-superlinear convergence can be established under mild conditions. Preliminary numerical experiments on the linear eigenvalue problem and the electronic structure calculation show the effectiveness of our method compared with the state-of-art algorithms.

This is a joint work with Bo Jiang, Lin Lin, Zaiwen Wen and Yaxiang Yuan.

Riemannian Optimization for Computing Low-rank Solutions of Lyapunov Equations with a New Preconditioner

Wen Huang

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Lyapunov equation plays a fundamental role in many applications such as signal processing, model reduction, and system and control theory. Here, we focus on solving the medium- to large-scale continuous Lyapunov equation $AXM + MAX = C$, by exploiting the structure of the problem. It is known that the solution has a low numerical rank under certain conditions. Therefore, various methods has been developed to compute a low-rank approximate solution of the Lyapunov equations. One state-of-the-art method is to use the Riemannian trust-region Newton method with an efficient preconditioner, in which it is assumed that the mass matrix M is an identity. In this presentation, we use a different Riemannian geometry and give a new efficient preconditioner without such assumption on M. Different combinations of Riemannian optimization methods with the preconditioner are tested. Numerical experiments are used to demonstrate the performance of the methods.

This is joint work with Bart Vandereycken at University of Geneva.

Recent Development on BCG-like Variants with Reduction of Loss of Orthogonality

Yanfei Jing

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The block conjugate gradient (BCG) method has always been considered to be attractive for solving symmetric positive definite (SPD) linear systems with multiple right-hand sides given simultaneously. When applied to ill-conditioned matrices (or rank deficiency situation, which can result ill-conditioned matrices) in finite precision arithmetic, the theoretical orthogonality among the computed vectors in the BCG-like methods may be lost, which may deteriorate the convergence rate seriously. In this talk, we report some recent development on BCG variants by employing effective strategies to respectively reduce two common cases of loss of orthogonality.

On the Equivalence of Inexact Proximal ALM and ADMM for a Class of Convex Composite Programming

Xudong Li

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In this talk, we show that for a class of linearly constrained convex composite optimization problems, an (inexact) symmetric Gauss-Seidel based majorized multi-block proximal alternating direction method of multipliers (ADMM) is equivalent to an inexact proximal augmented Lagrangian method (ALM). This equivalence not only provides new perspectives for understanding some ADMM-type algorithms but also supplies meaningful guidelines on implementing them to achieve better computational efficiency. Even for the two-block case, a by-product of this equivalence is the convergence of the whole sequence generated by the classic ADMM with a step-length that exceeds the conventional upper bound of $(1 + \sqrt{5})/2$, if one part of the objective is linear. This is exactly the problem setting in which the very first convergence analysis of ADMM was conducted by Gabay and Mercier in 1976, but, even under notably stronger assumptions, only the convergence of the primal sequence was known. A collection of illustrative examples are provided to demonstrate the breadth of applications for which our results can be used. Numerical experiments on solving a large number of linear semidefinite programming problems are conducted to illustrate how the theoretical results established here can lead to improvements on the corresponding practical implementations.

A Semismooth Newton Method for Support Vector Classification and Regression

Qingna Li

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Support vector machine is an important and fundamental technique in machine learning. In this paper, we apply a semismooth Newton method to solve two typical SVM models: the L2-loss SVC model and the ϵ-L2-loss SVR model. The semismooth Newton method is widely used in optimization community. A common belief on the semismooth Newton method is its fast convergence rate as well as high computational complexity. Our contribution in this paper is that by exploring the sparse structure of the models, we significantly reduce the computational complexity, meanwhile keeping the quadratic convergence rate. Extensive numerical experiments demonstrate the outstanding performance of the semismooth Newton method, especially for problems with huge size of sample data (for news20.binary problem with 19996 features and 1355191 samples, it only takes three seconds). In particular, for the ϵ-L2-loss SVR model, the semismooth Newton method significantly outperforms the leading solvers including DCD and TRON.

Low-rank Matrix Optimization Using Subspace Extraction

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In this paper, we study inexact first order methods on a large variety of low-rank matrix optimization problems related to eigenvalue computation. For traditional first order methods, at least one eigenvalue decomposition is performed at each iteration, which takes the most of the computational cost and is usually slow. In order to accelerate the methods, we consider inexact optimization methods using subspace extractions. We also analyze the convergence of the inexact methods. Preliminary numerical experiments on several matrix optimization problems show the effectiveness of the proposed algorithms, which usually provide multi-fold speedups for problems with low-rank solutions.

A Primal-Dual Interior-Point Relaxation Method for Nonlinear Programming

Xinwei Liu

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We present a primal-dual interior-point relaxation method for nonlinear programming problems, which is based on solving a particular logarithmic barrier positive relaxation problem with barrier and scaling parameters. A prominent feature of our method is that it does not require any primal or dual iterates to be interior-points, which provide a new approach for improving interior-point methods. A logarithmic barrier penalty function dependent on both primal and dual variables is used to prompt the global convergence of the method, where the penalty and barrier parameters are updated adaptively. Without assuming any regularity condition, it is proved that our method will terminate at an approximate KKT point of the original problem, or either an approximate infeasible stationary point or an approximate singular stationary point of the original problem will be found. Some preliminary numerical results are reported.

Several Key Mathematical Problems Arising from Simultaneous Localization and Mapping Based on Inertial Navigation and Robotic Vision

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The inertial-visual localization and simultaneous mapping technology has been successfully applied to augmented reality, drone navigation, robotic state estimation. Since that technology is complex and required to be achieved in real time, many works are focus on the image characteristics extraction and identification. There are few works on geometric properties and geometric algorithms of inertial motion differential equations. Therefore, in order to improve the accuracy of inertial navigation localization and reduce the computational complexity of mapping, we will discuss several key mathematical mathematical problems, which include geometric properties and algebraic structures of differential matrix equations for inertial navigation; and nonlinear least-squares problems arising from estimating coordinates of landmarks.

Robust Estimation through Huber Function

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In this talk I will present procedures for obtaining principal components and estimating common mean vector in a robust (to outliers) way. For both problems an optimization problem will be posed and a method for solving it efficiently will be presented. In general, these optimization problems are non-convex and no guarantees for finding the global optima. Numerical experiments on famous and synthetic datasets will illustrate the robustness of proposed methods.

Necessary Conditions of Optimality for the Nonlinear Optimal Control Problem with Delays and the Discontinuous Initial Condition

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For the optimal control problem with several constant delays in the phase coordinates and controls the necessary conditions of optimality are obtained for the initial and final moments, for delays having in the phase coordinates and the initial vector, for the initial function and control. The effect of the discontinuous initial condition is revealed.

A Penalty Method for Solving a Class of Structured Nonsmooth DC Constrained DC Programs

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In this talk, we consider a class of structured nonsmooth difference-of-convex (DC) constrained DC program. Pang et al. recently proposed a penalization approach for this problem that consists of finding an exact D-stationary point of a sequence of penalty subproblems. The convergence of their method was established under the pointwise Slater constraint qualification (PSCQ) and additionally an unusually strong assumption. Motivated by these, we propose a penalty method for the considered problem that consists of a sequence of much simpler penalty subproblems than those in the method proposed by Pang et al.. At each iteration our method only needs an approximate D-stationary point of the penalty subproblem, which can be found by an efficient method. Under a much weaker assumption, we show that any accumulation point of the sequence generated by our method is a B-stationary point of the problem if it satisfies the PSCQ.

This is a joint work with Professor Zhaosong Lu and Dr. Zirui Zhou.

New Gradient Method with Adaptive Stepsize Update Strategy

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In this work, a new stepsize update strategy for the gradient method is proposed. On one hand, the stepsizes are updated in a cyclic way, where the Cauchy steps are combined with fixed step lengths; on the other hand, the iteration number in one cycle is adjusted adaptively according to the gradient residue. Theorecially, the new method terminates in finite iterations for 3 dimensional convex quadratic function minimization problem; for general high dimensional problems, it converges R-linearly. Numerical results show the superior performance of the proposed method over the states of the art.

A Fast Proximal Point Method for Computing Exact Wasserstein Distance

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Wasserstein distance plays increasingly important roles in machine learning, stochastic programming and image processing. Major efforts have been under way to address its high computational complexity, some leading to approximate or regularized variations such as Sinkhorn distance. However, as we will demonstrate, regularized variations with large regularization parameter will degradate the performance in several important machine learning applications, and small regularization parameter will fail due to numerical stability issues with existing algorithms. We address this challenge by developing an Inexact Proximal point method for exact Optimal Transport problem (IPOT) with the proximal operator approximately evaluated at each iteration using projections to the probability simplex. The algorithm (a) converges to exact Wasserstein distance with theoretical guarantee and robust regularization parameter selection, (b) alleviates numerical stability issue, (c) has similar computational complexity to Sinkhorn, and (d) avoids the shrinking problem when applies to generative models. Furthermore, a new algorithm is proposed based on IPOT to obtain sharper Wasserstein barycenter.

On a TRUST-TECH Based Methodology for Integer Programming and Its Related Theory

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We propose a novel approach to guide deterministic and heuristic methods, as well as commercial solvers, for nonlinear integer programming. It aims to improve the solution quality by applying the TRUST-TECH methodology which includes an efficient mechanism for directing the search away from existing solutions and continuing to look for better solutions. Its effectiveness is examined by developing and simulating the TRUST-TECH guided branch-and-bound method and the TRUST-TECH guided commercial solvers, and comparing their performance with that of the original methods and solvers (e.g., GAMS/BARON, GAMS/SCIP, and LINDO/MINLP) and also with that of evolutionary-algorithm based methods. Simulation results show that the solution quality is substantially improved and global-optimal solutions are usually obtained after the application of TRUST-TECH. Moreover, using the techniques from dynamical systems, combinatorics, and dimension theory, we derive analytical results for assessing the computational complexity of this methodology.

Phase Retrieval with Background Information

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Phase retrieval, which is an inverse problem without standard uniqueness guarantee, has been a subject of intense algorithmic developments in various aspects. Under different settings, it is necessary to design different efficient models and solvers, and of course, provide the theoretical supports. In this paper, we consider the scenario that background information of the signal is available; and then, a model called phase retrieval with background information is proposed. With sufficient background information prior, we construct a loss function and apply the projected gradient descent method to search the ground truth. Theoretically, we first provide the uniqueness guarantee for the proposed model, and then prove that each stationary point admits the global optimum with probability 1. Next we present the convergence result of the corresponding projected gradient descent. Numerical simulations on 1-D and 2-D signals demonstrate the efficiency and robustness of the proposed model and algorithm.

Stochastic Trust Region Methods with Trust Region Radius Depending on Probabilistic Models

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We present a generic stochastic trust region scheme in which the trust region radius is directly associated with the random model. The proposed scheme is analyzed based on random models and random estimates of the objective function with certain probability provided some assumptions are satisfied. Specially, we show a specific algorithm STRME in which the trust region radius is linearly correlated with the 2-norm of the stochastic gradient. Moreover, the convergence complexity of STRME method in nonconvex, convex and strongly convex settings have all been analyzed. In the end, some numerical experiments are carried out to reveal the benefits of the proposed methods compared to the existing stochastic trust region methods and other related stochastic gradient methods.

When Inaccuracies in Value Functions do not Propagate on Optima and Equilibria

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We study general classes of dynamic optimization problems and dynamic games with feedback controls.

In such problems, the solution is found by using the Bellman or Hamilton-Jacobi-Bellman equation for the value function in the case of dynamic optimization and a set of such coupled equations for dynamic games. When the accurate analytic solution cannot be found, approximate methods can be used instead. This is extremely diffcult for dynamic games. There are examples showing that even a small error in solving the Bellman equation on very small subset of the set of states may lead to the resultant candidates for optimal control or equilibrium to be far from the actual one.

Currently, substantial focus in research by mathematicians is on high accuracy of the solution of the Bellman equation or the set of Bellman equations.

On the contrary, while studying a dynamic model with a singularity and known analytic solutions and, in order to test, purposely not using information about the type of the singularity, we have obtained suprisingly accurate approximation of optima and equilibria despite large errors in the value functions on some subsets, which was the starting point to this theoretical research.

We derive general rules stating what kind of errors in the calculation or computation of the value function does not result in errors in calculation or computation of an optimal control or a Nash equilibrium. This general result concerns not only errors resulting from using numerical methods but also errors resulting from some preliminary assumptions related to replacing the actual value functions by some a priori assumed constraints for them on certain subsets.

For the part of audience less familiar with dynamic optimization and dynamic games, there will be a short introduction to the subject.

The results are illustrated by a motivating example of the so called Fish Wars type of problems, with singularities in payoffs.

Sparsity Reconstruction using Nonconvex TGpV-Shearlet Regularization and Constrained Projection

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In many sparsity-based image processing problems, compared with the convex ℓ_1-norm approximation of nonconvex ℓ_0-norm, we can often preserve the structures better by taking full advantage of the nonconvex ℓ_p-norm ($0 \leq p < 1$). In this paper, we propose a nonconvex ℓ_p-norm approximation of total generalized variation (TGV)-shearlet regularization for constrained sparsity reconstruction. By introducing some auxiliary variables, the objective function has the separable structures, then we exploit an efficient alternating direction method of multipliers to solve the proposed model. Especially, we use a generalized iterated shrinkage operator to deal with the ℓ_p-norm subproblem, which is easy to implement. Extensive experimental results show, for different sampling ratios and noise levels, that the proposed nonconvex sparsity approximation outperforms some state-of-the-art algorithms in visual and quantitative measures.

An Incremental Gauss-Newton Method for L2 Regularized Finite Sum Problem

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Machine learning is a hot topic in which optimization is a fundamental tool. We consider large scale finite sum problems in machine learning, where the problem size n is large, the problem dimension is not very large and the residue is very small. It is generally thought that a stochastic or incremental method can be very effective in solving problems with large problem size since it has a cost independent of the problem size n per iteration. For ill-conditioning problems, a second order method should be applied. In particular, Quasi-Newton is a good choice and the Incremental Quasi-Newton(IQN) method succeeds in using Quasi-Newton method in an incremental framework. The small residual assumption encourages us to apply the Gauss-Newton method since it is simple and converges fast for zero-residual problems. The Incremental Gauss-Newton proposed here bridge a gap between deterministic and incremental Gauss-Newton method. Our method is appealing because it has a smaller computational cost per iteration than the standard Gauss-Newton method and achieves a linear convergence rate that is proportional to the residue under customary regularity assumptions. Besides this theoretical result, we show empirically on a number of well known datasets that the proposed IGN method is powerful. It is comparable to IQN in term of effective pass with less time for each iteration and a $O(nd)$ storage cost instead of $O(nd^2)$. Therefore, our method is effective in solving large scale finite sum problems with small residuals, which often appear in machine learning.

Variable Splitting Method for Matrix Optimization Problem with Symmetric Structure

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In this paper, we propose a variable splitting approach for a class of matrix optimization problems with orthogonal constraints and symmetric structure. Based on the symmetrically split variables in the original problems, we propose a simple smooth penalty model, where a quadratic penalty function is adopted to penalize the constraints introduced by our approach. We establish the equivalence between our model and the original problem under mild conditions and show that this approach can be extended to a wide range of matrix optimization problems. Based on the symmetrical characteristic of our model, we present an efficient alternating direction descent algorithm to solve our model. We prove the global convergence and local convergence rate for our algorithms under loose conditions. Preliminary experiments illustrate the potential of our algorithms.

Nonconvex Correction Approach for Robust Tensor Completion from Grossly Sparse Observations

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In this talk, we address the robust tensor completion problem for recovering a low-rank tensor image from limited samples and sparsely observations, especially corrupted by impulse noises. A convex relaxation of this problem is to minimize a weighted combination of tubal nuclear norm and the L1-norm data fidelity term. However the L1-norm may yield biased estimators and fail to achieve the best estimation performance. To overcome this limit, we propose a correction model, which minimizes a weighted combination of tubal nuclear norm, the L1-norm data fidelity term, and a concave smooth correction term. Through a linearization technique, we derive an inexact Gauss-Seidel difference of convex algorithm (GSDCA) to solve it. We prove that the iteration sequence generated by GSDCA converges to the critical point of the proposed model. Furthermore, we propose an accelerate GSDCA to speed up the convergence speed. Numerical experiments are provided to demonstrate the effectiveness of our methods. This is a joint work with Minru Bai, Michael K. Ng, and Defeng Sun.

Trust-region Method based on Inaccurate First-order Information

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As a fundamental tool in nonlinear optimization, trust-region method is considered to be classical and well understood. Its global convergence was established by Powell more than 40 years ago, and its worst-case complexity has been well studied recently. However, in the era of Data Science, we often find ourselves in scenarios that are not fully covered by such classical analysis. For example, the information required by the method may not always be available or reliable. Worse still, we may even feed the method with completely wrong information without being aware. These scenarios urge us to have a new look at the old method and understand it when classical assumptions fail.

We will discuss the behavior of trust-region method assuming that the objective function is smooth yet its gradient information available to us is inaccurate or even completely wrong. Both deterministic and stochastic cases will be investigated. It turns out that trust-region method is remarkably robust with respect to gradient inaccuracy. The method converges even if the gradient is evaluated with only one correct significant digit, and even if the gradient evaluation encounters random failures with probability 1/2. Indeed, in both situations, the worst case complexity of the method is essentially the same as when the gradient evaluation is always accurate.

This talk is based on joint works with Serge Gratton (University of Toulouse, INPT/ENSEEIHT) Clement W. Royer (Wisconsin-Madison) and Luis Nunes Vicente (Lehigh University).

The Rate of Convergence of Proximal Method of Multipliers for Nonlinear Semidefinite Programming

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The proximal method of multipliers was proposed by Rockafellar (1976) for solving convex programming and it is a kind of proximal point method applied to convex programming. In this paper, we apply this method for solving nonlinear semidefinite programming problems, in which subproblems have better properties than those from the augmented Lagrange method. We prove that, under the linear independence constraint qualification and the strong second-order suffciency optimality condition, the rate of convergence of the proximal method of multipliers, for a nonlinear programming problem, is linear and the ratio constant is proportional to $1/c$, where c is the penalty parameter that exceeds a threshold $c_* > 0$. Moreover, the rate of convergence of the proximal method of multipliers is superlinear when the parameter c increases to $+\infty$.

Completely Positive Tensors in Complex Field

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In this talk, we introduce the complex completely positive tensor, which has a symmetric complex decomposition with all real and imaginary parts of the decomposition vectors being nonnegative. Some properties of the complex completely positive tensor are given. A semidefinite algorithm is also proposed for checking whether a complex tensor is complex completely positive or not. If a tensor is not complex completely positive, a certificate for it can be obtained; if it is complex completely positive, a complex completely positive decomposition can be obtained.

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The organizing committee wishes you a pleasant stay in Shangrao!

Sanqing Mountain, Shangrao, China