
# The 7th International Conference on Numerical Optimization and Numerical Linear Algebra

August 16-19, 2009

Lijiang, Yunnan, China

# INTERNATIONAL CONFERENCE ON

# Numerical Optimization

# &

# Numerical Linear Algebra

August 16-19, 2009

Lijiang, Yunnan, China

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# Information for Participants

## Conference Hotel

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| Hotel Name: | *Yunnan Golden Spring Hotel, Lijiang* |
| Chinese Name: | 丽江金泉大酒店 |
| Hotel Address: | Middle Section of Shangri-La Avenue,<br>Lijiang, Yunnan, China. |
| Chinese Address: | 中国云南香格里拉大道中段 |
| Telephone: | +86-0888-5152888 |
| Conference Site: | Hotel Internal Meeting Room |
| Website: | http://lj.jqhotel.cn/index.php |

## Arrival

By air: There will be conference secretaries in Lijiang airport on August 15. They will help you to find the shuttle bus or to call a taxi to our conference hotel. The distance between Lijiang airport and our conference hotel is about 30km. It costs 15RMB/2USD to take the shuttle bus and about 55RMB/8USD to take a taxi. For the invited speakers, you will be picked up in the airport, if you have sent your arrival information to the organizing committee.

By coach: Lijiang coach station is close to our conference hotel.

## Registration

August 15, 10:00-22:00, in the lobby of our conference hotel. If you want to register at other time, please contact our conference secretary, Ms. Ji-ping Wu.

## Currency

Chinese currency is RMB. The current rate is about 6.83 RMB for 1 US dollar. The exchange of foreign currency can be done in the airport when you arrive. Please keep the receipt of the exchange so that you can change back to your own currency if you have Chinese currency left before you leave China. Money exchange is NOT possible in conference hotel, but you can ask the organizer committee for exchanging a small amount of currency. Foreign credit cards are NOT accepted in many shops in Lijiang.

## Contact Information

If you need any help, please contact the conference secretaries:

Ms. Ji-ping Wu: +86-136-9106-6084(in Chinese)
Dr. Xin Liu: +86-138-1000-2122

# Sponsors and Committee

## Sponsors

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## Organizing Committee of the Conference

| | | |
|---|---|---|
| Chairman : | Ya-Xiang Yuan | (Chinese Academy of Science) |
| Members : | Masao Fukushima | (Kyoto University) |
| | Yu-Hong Dai | (Chinese Academy of Science) |

## Conference Program

| | |
|---|---|
| August 15 | Registration |
| August 16-17 | Plenary and Contributed Talks |

*Check the* **Conference Schedule** *for detail*

| | |
|---|---|
| August 18-19 | Sightseeing in Shangri-La |

- *August 18* *Hutiaoxia*
- *August 19* *Pudachuo*

| | |
|---|---|
| August 20 | Departure day |

# 7th International Conference on Numerical Optimization and Numerical Linear Algebra

(August 16-19, 2009, Lijiang, Yunnan, China)

*Conference Schedule*

**16 August, Morning**

**7:00-8:00, Breakfast**

**Opening Ceremony**

| | |
|---|---|
| **08:00-08:15:** | Welcome Address |
| **08:15-08:30:** | Group Photo |

**Invited Talks (A1)**

**(Chair: Masao Fukushima)**

| | |
|---|---|
| **08:30-09:15, Tony Chan:** | From TV-L1 Model to Convex & Fast Optimization Models for Image & Geometry Processing |
| **09:15-10:00, Andrew R. Conn:** | A Derivative-Free Approach to Least-squares Minimization |

**10:00-10:10, Coffee Break**

**Invited Talks (A2)**

**(Chair: Li-qun Qi)**

| | |
|---|---|
| **10:10-10:50, Alfredo Noel Iusem:** | Convergence of Direct Methods for Paramonotone Variational Inequalities |
| **10:50-11:30, Yin Zhang:** | Sparse Solution Recovery via L1 or TV minimization: Theory, Models, and Algorithms |

**Contributed Talks (B1)**

**(Chair: Yu-hong Dai)**

| | |
|---|---|
| **11:30-11:50, Xiao-ling Sun:** | Improving SDP bounds for constrained 0-1 quadratic programs |
| **11:50-12:10, Hou-duo Qi:** | A Semidefinite Programming Study of the Elfving Theorem |
| **12:10-12:30, Mehi Al-Baali:** | On the Behaviour of a Family of Damped Quasi-Newton Methods |

**12:30-13:30, Lunch**

**16 August, Afternoon**

**Invited Talks (A3)**

**(Chair: Andreas Griewank)**

| | |
|---|---|
| **13:30-14:10, Zhi-jun Wu:** | Distance Geometry Optimization and Applications |
| **14:10-14:50, Zhong-xiao Jia:** | On Convergence of the Inexact Rayleigh Quotient Iteration without and with MINRES |

**Contributed Talks (B2)**

**(Chair: Tom Luo)**

| | |
|---|---|
| **14:50-15:05, Tomohiro Sogabe:** | A fast solver for generalized shifted linear systems with complex symmetric matrices |
| **15:05-15:20, Xiao-ping Xu:** | Minimal Distances of Lie Theoretic Codes |
| **15:20-15:35, Hung-Yuan Fan:** | The Iterative Refinement for Periodic Eigenvalue Problems |
| **15:35-15:50, Xin-wei Liu:** | A sequential quadratic programming method without a penalty function or a filter for nonlinear equality constrained optimization |

**15:50-16:00, Coffee Break**

## Contributed Talks (B3)

**(Chair: Nai-hua Xiu)**

| | |
|---|---|
| **16:00-16:15, Maria D. Gonzalez Lima:** | An Affine-Scaling Interior-Point CBB Method For Continuous Knapsack Constraints |
| **16:15-16:30, Zhe-ning Li:** | Approximation Algorithms for Homogeneous Polynomial |
| **16:30-16:45, Luis Mauricio Graña Drummond:** | A projected gradient method for vector optimization with relative error and inexact line searches |
| **16:45-17:00, Jing-jie Cao:** | Application of the Compressive Sensing in Seismic Signal Recovery |
| **17:00-17:15, Ling-feng Niu:** | A Parallel Decomposition Algorithm for Training Multi-class Kernel-based Vector Machines |

## Contributed Talks (B4)

**(Chair: Yun-bin Zhao)**

| | |
|---|---|
| **17:15-17:30, Chern-Shuh Wang:** | Perturbation Analysis for Palindromic Polynomial Eigenvalue Problems |
| **17:30-17:45, Gai-di Li:** | A cost-sharing method for the multilevel economic lot-sizing game |
| **17:45-18:00, Eric Chu:** | Linear palindromic pencils: numerical solution and applications |
| **18:00-18:15, Ming-hou Cheng:** | Sparse Two-Sided Rank-One Updates for Nonlinear Equations |
| **18:15-18:30, Xiao-dong Ding:** | A Parallel Extension of Model-Based Derivative-Free Optimization for Expensive Functions |

**18:30-20:00, Dinner**

17 August, Morning

**7:00-8:00, Breakfast**

**Invited Talks (A4)**

**(Chair: Tony Chan)**

| | |
|---|---|
| **08:00-08:40, Masao Fukushima:** | Numerical Methods for Generalized Nash Equilibria |
| **08:40-09:20, Li-qun Qi:** | Higher Order Positive Semi-Definite Diffusion Tensor Imaging and Space Tensor Conic Programming |
| **09:20-10:00, Tom Luo:** | Distributed Optimization in an Energy-constrained Network: Analog Versus Digital Communication Schemes |

**10:00-10:10, Coffee Break**

**Invited Talks (A5)**

**(Chair: Andrew R. Conn)**

| | |
|---|---|
| **10:10-10:50, Paul Tseng:** | On SDP and ESDP Relaxation for Sensor Network Localization |
| **10:50-11:30, Matthias Heinkenschloss:** | A Matrix-Free Trust-Region Sequential Quadratic Programming Method |

**Contributed Talks (B5)**

**(Chair: Zhi-jun Wu)**

| | |
|---|---|
| **11:30-11:50, Mu-sheng Wei:** | A Canonical Decomposition of the Right Invertible System and System Decoupling and Prescript Pole Assignment Problems |
| **11:50-12:10, Nai-hua Xiu:** | Analysis on Cone of Nonsymmetric Positive Semidefinite Matrices |
| **12:10-12:30, Yun-bin Zhao:** | Computation of Legendre-Fenchel transform of the product of quadratic froms |

**12:30-13:30, Lunch**

**17 August, Afternoon**

### Invited Talks (A6)

### (Chair: Yin Zhang)

| | |
|---|---|
| **13:30-14:10, Andreas Griewank:** | Use of adjoint based updates in equation solving and SQP |
| **14:10-14:50, Zhao-jun Bai:** | Optimization of Matrix Algorithms and Applications in Nano-Structure Simulations |

### Contributed Talks (B6)

### (Chair: Alfredo Noel Iusem)

| | |
|---|---|
| **14:50-15:05, Susana Scheimberg de Makler:** | A Perturbed Projection Method for a Nonmonotone Equilibrium Problem |
| **15:05-15:20, Bing-yu Li:** | Some results on condition numbers of the scaled total least squares problems |
| **15:20-15:35, Tsung-Ming Huang:** | Structure-Preserving Algorithm for Palindromic Polynomial Eigenvalue Problems |
| **15:35-15:50, Li-hong Zhi:** | Exact certification in global polynomial optimization via sums-of-squares of rational functions with rational coefficients |

**15:50-16:00, Coffee Break**

### Contributed Talks (B7)

### (Chair: Hou-duo Qi)

| | |
|---|---|
| **16:00-16:15, Li Chen:** | Tight Bounds on Some Risk Measures, with Applications to Robust Portfolio Selection |
| **16:15-16:30, Zhou-hong Wang:** | A New Proof for the Second-Order Optimality Conditions of Quadratic Programming |

**16:30-16:45, Takafumi Miyata:** Computation of Eigenvalues in Multiply Connected Region

**16:45-17:00, Li-ping Wang:** Relation between LCG and GMRES, and Two Hybrid Methods Based on LCG

**17:00-17:15, Xiao-guo Wang:** Cooperation vs. Noncooperation: A Study of Competitive Routing Game with Affine Linear Costs

## Contributed Talks (B8)

## (Chair: Xiao-ling Sun)

**17:15-17:30, Akira Imakura:** A Look-Back strategy for the GMRES(m) method

**17:30-17:45, Guang-min Wang:** An Application of Bilevel Programming Problem in Optimal Pollution Emission Price

**17:45-18:00, Ming-yun Tang:** Using Truncated Conjugate Gradient Method in Trust-Region Method with Two Subproblems and Backtracking Line Search

**18:00-18:15, Yun-shan Fu:** Improved Projected Gradient Algorithms for Singly Linearly Constrained Quadratic Programs subject to Lower and Upper Bounds

**18:15-18:30, Xin Liu:** On the Trust Region Subproblem for Nonlinear $L_1$ Norm Minimization Problem

**18:30-20:00, Dinner**

# Contents of Abstracts

# Part I

# Invited Lectures

# Optimization of Matrix Algorithms and Applications in Nano-Structure Simulations

Zhao-jun Bai
Department of Computer Science
Department of Mathematics
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Email: bai@cs.ucdavis.edu

Optimization of large scale linear algebra computations is a long-standing problem in numerical analysis and scientific computing communities. In this talk, we will present our synergistic effort in the past few years on the development of efficient and accurate numerical linear algebra solvers and applications in nano-structure simulations.

# From TV-L1 Model to Convex & Fast Optimization Models for Image & Geometry Processing

Tony Chan
University of California, Los Angeles and National Science Foundation
Email: tfchan@nsf.gov

A "classical" model for image denoising is the TV-L2 model, in which regularity is controlled by total variation and data fidelity is measured by the L2 norm. Recently, it has been recognized that a corresponding TV-L1 model has particularly attractive features and thus have received much study. The TV-L1 model not only possesses robust constrast-invariant properties, but it also leads to the convexification of several non-convex image processing models, making them less sensitive to initial guesses and faster to minimize. In this talk, we will review some of the recent developments in this area. We show how to convexify non-convex optimization problems including shape regularization, image segmentation, classification defined on an arbitrary graph, and the level set method in the context of free boundary problems. Another important advantage of using convex optimization models is to provide fast algorithms. We introduce continuous optimization algorithms based on operator spitting, which reveal to be faster than graph-cut combinatorial optimization techniques.

**Joint work with *Xavier Bresson* (UCLA)**

# A Derivative-Free Approach to Least-squares minimization

Andrew R. Conn
IBM-Thomas J. Watson Research Center, USA
Email: arconn@us.ibm.com

A framework for a class of derivative-free algorithms for the least-squares minimization problem will be described. Applications for such problems arise frequently. The algorithms use polynomial interpolation models and are designed to leverage the least-squares structure. Under suitable conditions, we establish global and local quadratic convergence. Numerical results indicate the algorithm is very efficient and robust for both low and high accuracy solutions. Comparisons will be made with two standard packages that do not exploit the special structure of the least-squares problem both derivative-free software and one that uses finite differences to approximate the gradients.

# Numerical Methods for Generalized Nash Equilibria

Masao Fukushima
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The generalized Nash game, or the generalized Nash equilibrium problem (GNEP), is a non-cooperative game where not only the players' cost functions but also their strategy sets depend on the rival players' strategies. The GNEP can be used to model a variety of interesting conflict situations in, for example, an electricity market and an international pollution control. However, a GNEP is known to be much more complicated structurally than the classical Nash equilibrium problem (NEP). In this talk, we give a brief overview of the recent development of computational methods for GNEPs.

# Use of adjoint based updates in equation solving and SQP

Andreas Griewank
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Email: griewank@mathematik.hu-berlin.de

We report on continuing work on the theory and application of low-rank updates that incorporate the so-called adjoint secant conditions. For nonlinear equations they yield superlinear convergence at the optimal R-order and reduce to GMRES or a limited memory variant on affine problems. For SQP we get a quadratic or bilinear computational effort per step and superlinear or controllable linear rate of convergence, respectively. We report numerical results from the usual test sets and three different applications, structure design for cars, pointwise evaluation of poly-convex hulls envelopes and minimzation of regularized deformation energies.

# A Matrix-Free Trust-Region Sequential Quadratic Programming Method

Matthias Heinkenschloss
Department of Computational and Applied Mathematics
Rice University, Houston, TX 77005-1892, US
Email: `heinken@rice.edu`

We present a matrix-free trust-region sequential quadratic programming (SQP) methods for the solution of large nonlinear programs (NLPs). The algorithms are motivated by the need to solve optimization problems governed by partial differential equations (PDEs).

SQP algorithms are the state-of-the-art for the solution of large-scale nonlinear programming problems. These methods have also been used for the solution of several partial differential equation (PDE) constrained optimization problems. However, for these problems, the rigorous application of SQP algorithms poses several challenges. One set of challenges arises from the need to solve the large-scale linear systems that arise inside SQP algorithms iteratively. These linear systems are optimality systems, so-called KKT systems, associated with quadratic programming subproblems which are governed by linearizations of the original PDE. For flow control problems and many other PDE constrained optimization problems, most of the computing time within an SQP method is spent on the solution of these quadratic programming subproblems. There are two avenues to reducing this cost. Controlling the level of exactness with which these subproblems have to be solved and devising effective preconditioners for the solution of these subproblems.

If the large-scale KKT systems arising inside SQP methods are solved iteratively, the optimization algorithm has to supply stopping tolerances to the linear system solver. Ideally, one wants to choose the stopping tolerances as large as possible, while still guaranteeing convergence of the overall algorithm. This has been studied intensively in the context of inexact Newton methods for large-scale systems of nonlinear equations. In the optimization context this task is significantly more difficult, since each SQP iteration requires the solution of several linear systems, the solutions of which interact. In this talk, I sketch our approach of designing implementable stopping criteria that ensure convergence of the SQP method while avoiding "over-solving" of the linear systems.

The performance of our overall solution approach is illustrated on PDE optimization problems.

# Convergence of Direct Methods for Paramonotone Variational Inequalities

J. Y. Bello Cruz[1] Alfredo Noel Iusem
Instituto de Matemática Pura e Aplicada, Estrada Dona Castorina 110, Jardim Botânico,
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Email: iusp@impa.br

We analyze one-step direct methods for variational inequality problems. The problem of interest, denoted VIP$(T, C)$, where $T : \mathbb{R}^n \to \mathcal{P}(\mathbb{R}^n)$ is a point-to-set operator and $C \subset \mathbb{R}^n$ is a closed and convex set, consists of finding $x^* \in C$ and $u^* \in T(x^*)$ such that $\langle u^*, y - x^* \rangle \geq 0$ for all $y \in C$. The iteration of the method is of the form $x^{k+1} = P_C(x^k - \alpha_k u^k)$, where $P_C$ denotex the orthogonal projection onto $C$, $u^k$ is an arbitrary element of $T(x^k)$, and $\{\alpha_k\}$ is an exogenous sequence of positive stepsizes satisfying some appropriate requirements. We prove that the sequence $x^k$ converges to a solution of VIP$(T, C)$ under the only assumptions of existence of solutions and paramonotocity of $T$, meaning that $T$ is monotone, and additionally, if $\langle u - v, x - y \rangle = 0$ with $u \in T(x)$ and $v \in T(y)$, then $u$ belongs to $T(y)$ and $v$ belongs to $T(x)$. Previous results on the method required much more demanding assumptions, like strong or uniform monotonicity, implying uniqueness of solution, which is not the case for our approach.

[1]Instituto de Matemática Pura e Aplicada, Estrada Dona Castorina 110, Jardim Botânico, CEP 22460-320 RJ, Rio de Janeiro, Brazil. Email: yunier@impa.br

# On Convergence of the Inexact Rayleigh Quotient Iteration without and with MINRES

Zhong-xiao Jia
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For the Hermitian inexact Rayleigh quotient iteration (RQI), we present general convergence results, independent of iterative solvers for inner linear systems. We prove that the method converges quadratically at least under a new condition, called the uniform positiveness condition. This condition can be much weaker than the commonly used one that at outer iteration $k$, requires the relative residual norm $\xi_k$ (inner tolerance) of the inner linear system to be smaller than one considerably and may allow $\xi_k \geq 1$. Our focus is on the inexact RQI with MINRES used for solving the linear systems. We derive some subtle and attractive properties of the residuals obtained by MINRES. Based on these properties and the new general convergence results, we establish a number of insightful convergence results. Let $\|r_k\|$ be the residual norm of approximating eigenpair at outer iteration $k$. Fundamentally different from the existing results that cubic and quadratic convergence requires $\xi_k = O(\|r_k\|)$ and $\xi_k \leq \xi \ll 1$ with $\xi$ fixed, respectively, our new results remarkably show that the inexact RQI with MINRES generally converges cubically, quadratically and linearly provided that $\xi_k \leq \xi$ with $\xi$ fixed not near one, $\xi_k = 1 - O(\|r_k\|)$ and $\xi_k = 1 - O(\|r_k\|^2)$, respectively. Since we always have $\xi_k \leq 1$ in MINRES for any inner iteration steps, the results mean that the inexact RQI with MINRES can achieve cubic, quadratic and linear convergence by solving the linear systems only with very low accuracy and very little accuracy, respectively. New theory can be used to design much more effective implementations of the method than ever before. The results also suggest that we implement the method with fixed small inner iteration steps. Numerical experiments confirm our results and demonstrate much higher effectiveness of the new implementations.

# Distributed Optimization in an Energy-constrained Network: Analog Versus Digital Communication Schemes

Tom Luo
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We consider a distributed optimization problem whereby a network of $n$ nodes, $S_\ell$, $\ell \in \{1, \ldots, n\}$, wish to minimize a common strongly convex function $f(\mathbf{x})$, $\mathbf{x} = [x_1, \ldots, x_n]^T$, under the constraint that node $S_\ell$ controls variable $x_\ell$ only. The nodes locally update their respective variables and periodically exchange their values over a set of pre-defined communication channels. Previous studies of this problem have focused mainly on the convergence issue and the analysis of convergence rate. In this work, we consider noisy communication channels and study the impact of communication energy on convergence. In particular, we study the minimum amount of communication energy required for nodes to obtain an $\epsilon$-minimizer of $f(\mathbf{x})$ in the mean square sense. For linear analog communication schemes, we prove that the communication energy to obtain an $\epsilon$-minimizer of $f(\mathbf{x})$ must grow at least at the rate of $\Omega(1/\epsilon)$, and this bound is tight when $f$ is convex quadratic. Furthermore, we show that the same energy requirement can be reduced to $O(\log^3 1/\epsilon)$ if digital communication schemes are used.

# Higher Order Positive Semi-Definite Diffusion Tensor Imaging and Space Tensor Conic Programming

Li-qun Qi
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Due to the well-known limitations of diffusion tensor imaging (DTI), high angular resolution diffusion imaging (HARDI) is used to characterize non-Gaussian diffusion processes. One approach to analyze HARDI data is to model the apparent diffusion coefficient (ADC) with higher order diffusion tensors (HODT). The diffusivity function is positive semi-definite. In the literature, some methods have been proposed to preserve positive semi-definiteness of second order and fourth order diffusion tensors. None of them can work for arbitrary high order diffusion tensors. In this paper, we propose a comprehensive model to approximate the ADC profile by a positive semi-definite diffusion tensor of either second or higher order. We call this model PSDT (positive semi-definite diffusion tensor). PSDT is a convex optimization problem with a convex quadratic objective function constrained by the nonnegativity requirement on the smallest Z-eigenvalue of the diffusivity function. The smallest Z-eigenvalue is a computable measure of the extent of positive definiteness of the diffusivity function. We also propose some other invariants for the ADC profile analysis. Performance of PSDT is depicted on synthetic data as well as MRI data.

PSDT can also be regarded as a conic linear programming (CLP) problem. Yinyu Ye and I investigated PSDT from the viewpoint of CLP. We characterize the dual cone of the positive semi-definite space tensor cone, and study the CLP formulation and duality of the positive semi-definite space tensor programming (STP) problem.

# On SDP and ESDP Relaxation for Sensor Network Localization

Paul Tseng
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Recently Wang, Zheng, Boyd, and Ye proposed a further convex relaxation of the SDP relaxation for the sensor network localization problem, called edge-based SDP (ESDP). The ESDP is easier to solve than the SDP and, in simulation, yields solution about as accurate as the SDP relaxation. We show that, when the distance measurements are exact, we can determine precisely which sensors are correctly positioned in an ESDP interior solution by checking if their individual traces are zero. On the other hand, when the distance measurements are inexact, this check is unreliable for both ESDP and SDP solutions. We then propose a noise-aware version of ESDP relaxation for which small individual trace is a reliable check of sensor position accuracy. Moreover, the position error for such a sensor is in the order of the square root of its trace. We propose a coordinate gradient descent method, using log-barrier penalty, to find an ESDP interior solution. This method is more efficient than interior-point method and is implementable in a distributed manner.

**Joint work with *Ting Kei Pong***

# Distance Geometry Optimization and Applications

Zhi-jun Wu
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A distance geometry problem is to find the coordinates for a set of points in a given metric space given the distances for the pairs of points. The distances can be dense (given for all pairs of points) or sparse (given only for a subset of all pairs of points). They can be provided with exact values or with small errors. They may also be given with a set of ranges (lower and upper bounds). In any case, the points need to be determined to satisfy all the given distance constraints. The distance geometry problem has many important applications such as protein structure determination in biology, sensor network localization in communication, and multidimensional scaling in statistical classification. The problem can be formulated as a nonlinear system of equations or a nonlinear least-squares problem, but it is computationally intractable in general. On the other hand, in practice, many problem instances have tens of thousands of points, and an efficient and optimal solution to the problem is required. In this talk, I will give a brief review on the formulation of the distance geometry problem and its solution methods. I will then present a so-called geometric buildup method and show how it can be applied to solve a distance geometry problem efficiently and deal with various types of distance data, dense or sparse, exact or inexact, effectively. I will also show how the method can be applied to a set of distance bounds and obtain an ensemble of solutions to the problem. Some computational results on protein structure determination and sensor network localization will be demonstrated.

# Sparse Solution Recovery via L1 or TV minimization: Theory, Models, and Algorithms

Yin Zhang
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L1 and Total Variation (TV) minimization plays a central role in Compressive Sensing (CS), an emerging methodology in signal and image processing that utilizes sparsity to reduce the amount of data necessary for signal encoding. We will introduce a new analysis that improves the theory for CS developed by Candes, Romberg and Tao. We also discuss the derivations of versatile and efficient first-order algorithms based on classic ideas of duality, augmented Lagrangian, variable splitting and alternating minimization.

# Part II

# Contributed Talks

# On the Behaviour of a Family of Damped Quasi-Newton Methods

Mehiddin Al-Baali
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The damped BFGS method of Powell (1978), in an SQP method for constrained minimization, has been extended recently to unconstrained optimization. Further extension to a restricted family of quasi-Newton methods will be considered. This damped family resample that of Broyden, except that the change in gradients, which appears in the Broyden family of updating formulae, is replaced by a certain modified vector so that the Hessian approximations are maintained safely positive definite. Other properties and numerical experience will be described. It will be shown that the damped updates perform substantially better than the unmodified updates as well as other recent modified updates.

# Application of the Compressive Sensing in Seismic Signal Recovery

Jing-jie Cao, Yan-fei Wang, Chang-chun Yang
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Seismic signal recovery as a part of seismic processing is very important in geophysical inverse problems. The representation for noisy seismic data can now be written as [3,4,6,9] d=Lm+n, where $d$ is the data contaminated by noise $n$; $L$ is the modeling matrix; and $m$ the layer reflectivity which we want to find. The collected seismic data $d$ are often subsampled data with missing traces because of the physical limitation, this underdetermined problem is often usually hard to correct recovery. In addition, the amount of seismic data is usually large, thus how to recover the full wavefield from subsampled data is also meaningful by reducing the number of shots and receivers. The recently developed compressive sampling theory can recovery the full signals from subsampled information based on some a priori information. The success of this theory is based on three main ingredients, namely, the sparse transform, the random sampling strategy and a proper optimization method which can solve a restricted norm optimization [1,2,5,7,8]. In this paper, we study using this theory combined with a sparse transform to the seismic data recovery problem. The numerical result of synthetic data shows that this theory is promising for seismic data processing.

**keywords:** Seismic data recovery; Inverse problems; Compressive sampling; Sparse transform; norm optimization.

# Tight Bounds on Some Risk Measures, with Applications to Robust Portfolio Selection

Li Chen, Si-mai He[1] Shu-zhong Zhang[2]
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The Chinese University of Hong Kong, Shatin, Hong Kong.
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In this paper we develop tight bounds on the expected values of several risk measures that are of interest to us. This work is motivated by the robust optimization models arising from portfolio selection problems. The basic setting is to find a portfolio which maximizes (respectively minimizes) the expected utility (respectively disutility) values, in the midst of infinitely many possible ambiguous distributions of the investment returns satisfying the given mean and variance conditions. First, we show that the single-stage portfolio selection problem within this framework whenever the disutility function is in the form of *Lower Partial Moments* (LPM) or *Conditional Value at Risk* (CVaR) can be solved analytically. The results lead to the solutions for single-stage robust portfolio selection models. The results also lead to a multi-stage *Adjusted Robust Optimization* (ARO) solution when the disutility function is the second order LPM. Beyond the confine of convex optimization, we also consider the so-called S-shaped value function. The non-robust version of the problem is shown to be NP-hard in general. However, we present an efficient procedure for solving the robust counterpart of the same portfolio selection problem. In this particular case, the consideration of the robustness actually helps to reduce the computational complexity. Finally, we consider the situation where the chance of a quadratic mapping of the distribution above a threshold is also known. That information will help to further reduce the ambiguity in the robust model. We prove that robust portfolio problems in such settings can be solved by means of Semidefinite Programming (SDP), if no more than two such additional chance inequalities are present.
**keywords:** Portfolio selection, robust optimization, S-shaped function, Chebyshev inequality.

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# Sparse Two-Sided Rank-One Updates for Nonlinear Equations

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The two-sided rank-one (TR1) update method was introduced by Griewank and Walther (2002) for solving nonlinear equations. It generates dense approximations of the Jacobian and thus is not applicable to large-scale sparse problems. To overcome this difficulty, we propose sparse extensions of the TR1 update and give some convergence analysis. The numerical experiments show that some of them are superior to the TR1 update method.

**Key words:** TR1 update, Broyden Rank One update, Sparsity.

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# Linear Palindromic Pencils: Numerical Solution and Applications

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Palindromic eigenvalue problems occur in many important applications, such as vibration analysis of fast trains, surface acoustic wave filters and sensors, crack modelling, exterior problems and optimal control. One popular solution technique is to linearize higher order problems to the form $(A - \lambda A^*)z = 0$. In this paper, we shall discuss some of these applications and consider how the linear palindromic eigenvalue problem can be solved in a structure-preserving way.

# A Stochastic Approximation Algorithm via Quadratic Approximation and Least Squares

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The stochastic approximation problem is to find some root of or minimize a nonlinear function in the presence of noise. The fundamental approach for stochastic approximation is the Robbins-Monro algorithm. To stabilize the approach, the technique of averaging the previous measures of the gradients has been well studied by quite many researches. In this work, we study the stochastic approximation problem with the presence of Gaussian noise. We shall consider the quadratic approximation model for the real function and calculate the new iterates via the minimization of some suitable least squares problem. Numerical results are also reported, which demonstrated the efficiency of the new algorithm.

**Key words:** Stochastic Approximation, Quadratic Approximation, Least Squares.

**Joint work with Zi Xu(Shanghai University)**

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# A Parallel Extension of Model-Based Derivative-Free Optimization for Expensive Functions

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Derivative-free optimization involves the methods used to minimize an objective function when its derivatives are unavailable. Model-based methods are those based on modeling the objective function by multivariate interpolation in combination with the trust-region techniques. However, for many real-world problems, the objective functions are usually computationally expensive. In order to decrease the number of iterations, we do parallel evaluations at different positions in each iteration so that iterative points with lower function value as well as better interpolation models can be obtained, compared with serial version. Well poisedness is also ensured. Numerical results show that it gives some non-negligible improvements.

# A Projected Gradient Method for Vector Optimization with Relative Error and Inexact Line Searches

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We propose an inexact projected gradient-like method for general constrained vector optimization problems. The method admits relative errors on the search directions and the stepsizes are chosen using an Armijo-like rule, implemented with a backtracking procedure. Under some reasonable hypotheses, global convergence to weakly efficient points of all sequences produced by the method is established for convex (respect to the ordering cone) objective functions.

# The Iterative Refinement for Periodic Eigenvalue Problems

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In this talk we study the Rayleigh-Ritz approximation for the eigenproblem of periodic matrix pairs. We show that the convergence of the Ritz values and corresponding periodic Ritz vectors. Furthermore, we prove the convergence of the refined periodic Ritz vectors and propose a reliable algorithm for their computation. The numerical results illustrate that the refinement procedure produces excellent approximations to the original periodic eigenvectors.

# Improved Projected Gradient Algorithms for Singly Linearly Constrained Quadratic Programs subject to Lower and Upper Bounds

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In this paper, we consider the projected gradient algorithms for solving the quadratic program with bound constraints and a single linear equality constraint(SLBQP). We establish the relationship between the Lagrangian multiplier in the projection subproblem and the Lagrangian multiplier in the original optimization problem. Then we give an improved initial estimate of the Lagrangian multiplier in the subproblem based on this relationship. It appears that this initial estimate is very close to the optimal Lagrange multiplier after several iterations of the outer iterations. This will reduce at most 40% of the computing time in the projection subproblem. This initial guess can also be used in all kinds of projected gradient methods for solving the SLBQP problem. The numerical results show that it brings much more improvement in monotone algorithms than in nonmonotone algorithms. We also apply the adaptive steepest descent step-size and the Dai-Yuan step-size which are two monotone step-sizes to the projected gradient method of this SLBQP problem. Our numerical experiments showed that their performance can be better than some other monotone projected gradient methods.

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# An Affine-scaling Interior-Point CBB Method For Continuous Knapsack Constraints

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We develop an affine-scaling algorithm for optimization problems with a single linear equality constraint and box restrictions. The algorithm has the property that each iterate lies in the relative interior of the feasible set. The search direction is obtained by approximating the Hessian of the objective function in Newton's method by a multiple of the identity matrix. When the approximation is given by the cyclic Barzilai-Borwein (CBB) formula, we obtain our ASL-CBB scheme (affine scaling interior point method for Kanpsack constraints). Global convergence is established for a nonmonotone line search.

The algorithm is particularly well suited for optimization problems where the Hessian of the objective function is a large, dense, and possibly ill-conditioned matrix. As an application we consider the Support Vector Machines.

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# Structure-Preserving Algorithm for Palindromic Polynomial Eigenvalue Problems

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Consider the $(\star, \varepsilon)$-palindromic polynomial eigenvalue problem (PPEP) with degree $2d$ of the form

$$\mathcal{P}(\lambda)x \equiv \left( \sum_{j=0}^{d-1} \lambda^{2d-j} A_{d-j}^{\star} + \lambda^d A_0 + \varepsilon \sum_{j=1}^{d} \lambda^{d-j} A_j \right) x = 0, \tag{1}$$

where $\lambda \in \mathbb{C}$, $x \in \mathbb{C}^n \backslash \{0\}$, $A_j \in \mathbb{C}^{n\times n}$, for $j = 0, 1, \ldots, d$, $A_0^{\star} = \varepsilon A_0$, $\varepsilon = \pm 1$ and "$\star$" denotes either "H" (Hermition/conjugate transpose) or "T" (transpose). The scalar $\lambda$ and the nonzero vector $x$ in (1) are the eigenvalue and the associated eigenvector of $\mathcal{P}(\lambda)$, respectively. The equation (1) is also called a $\star$-PPEP if $\varepsilon = 1$ or a $\star$-anti-PPEP, if $\varepsilon = -1$.

The underlying matrix $\mathcal{P}(\lambda)$ in (1) has the property that reversing the order of the coefficients, followed by taking the (conjugate) transpose, leads to the original matrix polynomial (anti-)invariant, which explains the world "(anti-)palindromic". Consequently, taking the (conjugate) transpose of (1), we easily see that the eigenvalues of $\mathcal{P}(\lambda)$ satisfy a "symplectic" property, that is, they are paired with respect to the unit circle, containing both eigenvalues $\lambda$ and $1/\lambda^{\star}$.

In this talk, we mainly propose a structured quadraticization to transform even degree palindromic polynomial eigenvalue problems (PPEPs) into palindromic quadratic eigenvalue problems (PQEPs), instead of the structured linearization to palindromic generalized eigenvalue problems (PGEPs). Then, the structure-preserving algorithm for solving PQEPs based on $(\mathcal{S} + \mathcal{S}^{-1})$-transformation and Patel's algorithm 1993 can be applied directly to solve PPEPs. Numerical experiments show that the backward error for PPEP computed by PQEP is better than that by PGEP and the standard GEP ("polyeig" in MATLAB).

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# A Look-Back strategy for the GMRES(m) method

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Large, sparse, real, and nonsymmetric linear systems of the form

$$Ax = b, \quad A \in \mathbf{R}^{n \times n}, \quad x, b \in \mathbf{R}^{n}$$

arise from discretization of the partial differential equations in the field of the computational science and engineering. Since it is often the most time-consuming part of a computation, the solution of the linear systems are central to many numerical simulations. The solvers for the linear systems are divided into direct methods and iterative methods, and the iterative methods are classified into stationary iterative methods and Krylov subspace methods. Recently, the Krylov subspace methods have been extensively researched for fairly large and sparse linear systems.

The GMRES method [1] of Saad and Schultz is well-known as the typical Krylov subspace method for nonsymmetric linear systems. While the GMRES method shows a good convergence, it has some difficulties in storage and computational costs. To remedy these difficulties, the technique so-called restart is generally used as a practical choice. The restarted version of the GMRES method is called the GMRES(m) method [1].

In each restart of the GMRES(m) method, the initial guess is fixed on the approximate solution obtained at previous restart. In this talk, we focus on this fixed initial guess, and then, we are motivated by this question "if let the initial guess of each restart of the GMRES(m) method be free, what happens?"

Our main goal of this talk is to answer this question and to propose a Look-Back strategy for the GMRES(m) method based on the answer to the question. The proposed method will be shown to be competitive with the traditional GMRES(m) method.

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# Some results on condition numbers of the scaled total least squares problems

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Under the Golub-van Loan condition for the existence and uniqueness of the scaled total least squares(STLS) solution, we study perturbation analysis and condition numbers of the STLS problems by means of the optimization formation of the STLS problem. Comparing with some existing related results, our estimates for the condition numbers are easier to calculate in some sense. For some structured STLS problems arising from applications we embed the special structure into the perturbation analysis and derive the structured condition numbers. We also consider the relation between the structured condition numbers and the general condition numbers.

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# A cost-sharing method for the multilevel economic lot-sizing game

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Our main result is a $2\beta(2\beta+1)-$approximate cost recovery, cross-monotonic, and competitive cost-sharing method for the multi-level economic lot-sizing game, assuming the weak triangle inequality. This result extends that of the recent 1-level economic lot-sizing game of Xu and Yang (2009).

**Keywords:** Multi-level economic lot-sizing game, cross-monotonic, competitive, approximate cost recovery.

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# Approximation Algorithms for Homogeneous Polynomial Optimization with Quadratic Constraints

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We consider approximation algorithms for optimizing a generic multi-variate homogeneous polynomial function, subject to homogeneous quadratic constraints. Such optimization models have wide applications, e.g., in signal processing, magnetic resonance imaging (MRI), data training, approximation theory, and portfolio selection. Since polynomial functions are non-convex in general, the problems under consideration are all NP-hard. We shall focus on polynomial-time approximation algorithms. In particular, we consider maximization of a homogeneous polynomial over the intersection of ellipsoids centered at the origin, and propose polynomial-time approximation algorithms with provable worst-case performance ratios, which are shown to depend only on the dimensions of the models. Numerical results are reported, illustrating the effectiveness of the approximation algorithms studied.

**Joint work with *Simai HE* and *Shuzhong ZHANG***

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# On the Trust Region Subproblem for Nonlinear $L_1$ Norm Minimization Problem

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In this talk, the trust region subproblem for nonlinear $L_1$ norm minimization problem is considered. We prove that this kind of nonsmooth trust region subproblem is NP-hard, and propose a sequential 2-dimensional subspace minimization method for it. The convergence properties are also studied.

**Key words:** $L_1$ norm minimization, nonsmooth optimization, trust region method, NP-hard least distance problem, sequential 2-dimensional subspace minimization method.

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# A sequential quadratic programming method without a penalty function or a filter for nonlinear equality constrained optimization

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We present a sequential quadratic programming method without using a penalty function or a filter for solving nonlinear equality constrained optimization. In each iteration, the linearized constraints of quadratic programming are relaxed to satisfy two mild conditions, the step-size is selected such that either the value of objective function or the measure of constraint violations is reduced sufficiently. As a result, our method has two nice properties. Firstly, we do not need to assume the boundedness of the iterative sequence; Secondly, we do not need any restoration phase which is necessary for filter methods. We prove that either every limit point of the sequence generated by the method is a feasible point with at least one of which being a Karush-Kuhn-Tucker point, or there is a limit point which is either a Fritz-John point or an infeasible stationary point. By controlling the exactness of linearized constraints and introducing a second-order correction technique, without requiring linear independence constraint qualification, the algorithm is shown to be locally superlinearly convergent. The numerical results show that the algorithm is more effective than that using a penalty function.

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# A Perturbed Projection Method for a Nonmonotone Equilibrium Problem

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In this work we analyse an iterative method for an equilibrium problem in a Hilbert space $H$ which involves a closed convex set $C$ an a bifuction $f : H \times H \to (-\infty, \infty]$ with $C \times C \subseteq dom(f)$ such that $f(x, \cdot)$ is convex and Gateux-differentiable at $x$, for all $x \in C$. The corresponding $G$-derivate is denoted by $F_y(x, \cdot)(x)$. We develop an iterative method involving inexact projections onto convenient approximations of the constraint set $C$. It is an implementable algorithm since at each iteration, only one projection onto a simple approximation set of $C$ (like a polyhedron) is calculated. We do not requiere any kind of monotonicity on the bifunction $f$. We obtain that the sequence generated by the algorithm, $\{x^k\}$ has cluster limit points assuming that the solution set of the equilibrium problem is nonempty and a weak cocoercivity condition on $F_y(x, \cdot)(x)$. We also deduce that $\{x^k\}$ is an asymptotically solving sequence of the problem. When we consider some kind of continuity on $F_y(x, \cdot)(x)$ or on $f(\cdot, y)$, used in the literature for this problem, we derive that each cluster point is a solution of the problem. Moreover, we establish that the whole sequence is weakly convergent to a solution of the equilibrium problem if $F_y(x, \cdot)(x)$ is cocoercive on $C$ respect to the solution set, reminding weaker than the classic cocoercitivity condition.

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# Computation of Eigenvalues in Multiply Connected Region

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In this talk, we consider the solution of eigenvalues in a finite and multiply connected region. Such problems arise in the application of photonic crystal waveguides and there is a strong need for the fast solution of the problems. For solving the problems efficiently, we extend the Sakurai-Sugiura method which has been proposed for simply connected region. We also analyze the error of the computed eigenvalues.

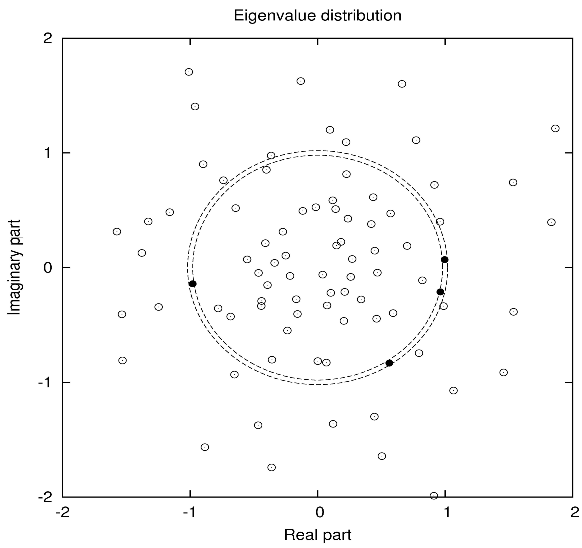


Fig.1: The four desired eigenvalues in doubly connected region are shown by mark • and the other eigenvalues are shown by mark ◦.

# A Parallel Decomposition Algorithm for Training Multiclass Kernel-based Vector Machines

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We present a decomposition method for training Crammer and Singer's multiclass kernel-based vector machine model. A new working set selection rule is proposed. A special projected gradient method is designed to solve the quadratic subproblem efficiently by exploiting the structure of the constraints. Parallel strategies are given to utilize the storage and computational resources available on multiprocessor system. Global convergence of the new algorithm is established. Numerical experiment on benchmark problems demonstrates that good classification accuracy and remarkable time saving can be achieved in practice.

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# A Semidefinite Programming Study of the Elfving Theorem

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The theorem of Elfving is one of the most important and earliest results that have led to the theory of optimal design of experiments. This paper presents a fresh study of it from the viewpoint of modern semidefinite programming. There is one-to-one correspondence between solutions of the derived semidefinite programming problem (SDP) and $c$-optimal designs. We also derive a uniqueness theorem that ensures unique optimal design without assuming the linear independence property over the largest set of supporting points. The SDP can also be cast as an $\ell_1$-convex programming that has recently been extensively studied and often yields sparse solutions. Our numerical experiments on the trigonometric regression model confirm that the SDP does produce a sparse optimal design.

# A Fast Solver for Generalized Shifted Linear Systems with Complex Symmetric Matrices

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We consider the solution of complex symmetric generalized shifted linear systems of the form

$$(A + \sigma_i B)\boldsymbol{x}^{(i)} = \boldsymbol{b}, \quad i = 1, 2, \ldots, m, \tag{2}$$

where $A \in \mathcal{R}^{n\times n}$ is symmetric, $B \in \mathcal{R}^{n\times n}$ is symmetric positive definite, and $\sigma_i \in \mathcal{C}$ for $i = 1, \ldots, m$, and we note that the coefficient matrices $A + \sigma_i B$ are complex symmetric but not Hermitian. The systems (2) arise in large scale electronic structure theory, and there is a strong need for fast solution of the systems. When the matrix $B = I$ (identity matrix), the systems (2) reduce to well-known (standard) shifted linear systems. Some fast iterative solvers for the standard shifted linear systems have been recently proposed, e.g., [1,2].

In this talk, we present a fast iterative solver for the systems (2). The iterative solver is obtained by the use of the following two ideas:

1. Shift invariance property of Krylov subspaces;
2. A suitable choice of bilinear forms.10

The first idea plays an important role in dramatically reducing the computational costs, and the second one leads to low memory requirement. Numerical results will show the efficiency of the iterative solver.

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# Improving SDP Bounds for constrained 0-1 quadratic programs

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We investigate semidefinite programming (SDP) relaxations for linearly constrained 0-1 quadratic programs. Two classes of problems are considered: linear equality constrained 0-1 quadratic program and quadratic knapsack program. We first discuss the duality gap between the equality constrained binary quadratic program and its SDP relaxation. The SDP bound is improved by using the distance from $\{-1, 1\}^n$ to certain affine subspace, while the computation of this distance can be achieved by the cell enumeration of hyperplane arrangement. For quadratic knapsack problem, we show that the SDP relaxation of quadratic knapsack problem does not always possess a unique optimal solution. This is in contrast with the unconstrained 0-1 quadratic problem where the SDP relaxation always has a unique optimal solution. We then derive a necessary and sufficient condition to ensure the uniqueness of the SDP relaxation solution for QKP. It is shown that the SDP bound can be also improved using the distance from set $\{0, 1\}^n$ to certain polyhedral set.

# Using Truncated Conjugate Gradient Method in Trust-Region Method with Two Subproblems and Backtracking Line Search

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A trust-region method with two subproblems and backtracking line search for solving unconstrained optimization is proposed. At every iteration, we use the truncated conjugate gradient method or its variation to approximately solve one of the two subproblems. Backtracking line search is carried out when the trust-region trail step fails. We show that this method is global convergence and has local superlinear convergence rate when the Hessian matrix of the objective function at the local minimizer is positive definite. Numerical results show that this method is as reliable as the traditional trust-region method and more efficient in respect of iterations, CPU time and evaluations.

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# Perturbation Analysis for Palindromic Polynomial Eigenvalue Problems

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In this talk, we shall give some structured perturbation analysis for palindromic polynomial eigenvalue problems. We also survey some current results in the literatures.

# An Application of Bilevel Programming Problem in Optimal Pollution Emission Price

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Charging for the pollution is one of the ways to enhance the environmental quality, which is a hot topic now. The appropriate price of the pollution emission is the most important question of the research on how to charge for the pollution. So, by constructing a bilevel programming model, we provide a novel way for solving the problem of charging for the pollution. In our model, the government (or the social regulation) chooses the optimal price of the pollution emission with consideration to firms' response to the price. While the firms choose their optimal quantities of the production to maximize their profits at the given price of the pollution emission. Finally, a simple example is illustrated to demonstrate the feasibility of the proposed model.

# Relation between LCG and GMRES, and Two Hybrid Methods Based on LCG

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This talk tries to discuss the relation between the left conjugate gradient (LCG) and GMRES. It is well known that LCG is a *Galerkin* method with residual orthogonal to the Krylov subspace, while GMRES is residual norm-minimizing one. So we firstly consider the mathematical equivalence of LCG and the full orthogonalization method (FOM), which is also a *Galerkin* method and has the same basis in Krylov subspace as GMRES. Then a relationship between FOM and GMRES can be used to evaluate the residual quantity and establish the convergence theory of LCG. In order to make a good use of the advantage of LCG to directly construct approximate solutions in iterations and the residual norm-minimization of GMRES, two hybrid algorithms LCGR and LCGO will be proposed. Numerical experiments show that two hybrid methods do improve the convergence of the standard LCG and GMRES, also the comparable methods GMRESR and GCRO.

**keywords:** left conjugate gradient method, *Galerkin* methods, residual norm-minimizing, GMRESR, GCRO.

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# Cooperation vs. Noncooperation: A Study of Competitive Routing Game with Affine Linear Costs

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In this paper we consider the competitive routing game with affine linear unit cost on each link. The aim of the research is to explore the connection between the cooperative and noncooperative game theory, including the benefit/cost analysis in the face of cooperation versus noncooperation. For the general network, the price of anarchy is shown to be bounded above by $\frac{2K}{K+1}$ , where $K$ is the number of players. In the parallel network, the cooperation can be viewed as the mergence of players' required flow. Based on the argument of directional derivatives, it is showed that if some players cooperate, the total cost of the coalition members may increase, while other players will benefit from the cooperation and in total, and the social cost will decrease. As a consequence, we can identify the worst case of price of anarchy for any given number of players when the total flow demands are known. Also, it is shown that in the case of parallel network, the price of anarchy is bounded by $\frac{4K^2}{3K^2+2K-1}$ , which is tight in the worst case.

**keywords:** Competitive routing game, Nash equilibrium, cooperation, price of anarchy.

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# A New Proof for the Second-Order Optimality Conditions of Quadratic Programming

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The second-order optimality conditions for quadratic programming problems is studied. The main result in this direction was published by Majthay in 1971, Contesse in 1980 and Mangasarian 1980 etc. But the proof for the main result is long and complicated. This paper will give constructive and shorter proof for the main result. The implications of the result for general nonlinear constrained programming is also discussed.

# A canonical decomposition of the right invertible system and system decoupling and prescript pole assignment problems[3]

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In the literature, several canonical decompositions of the system $\{C, A, B\}$ have been derived for different applications. In this paper we deduce several rank relations related to the matrices of the system $\{C, A, B\}$ to obtain the necessary and sufficient condition for the system being right invertible, and propose a new canonical decomposition of the right invertible system. From this decomposition, we study the Smith form of the matrix pencil $P(s) = \begin{pmatrix} A - sI & B \\ C & 0 \end{pmatrix}$ to find out the finite zeros and infinite zeros of $P(s)$, the range of the ranks of $P(s)$ for $s \in C$, and the controllability of the right invertible system.

We will apply this canonical decomposition of the right invertible system $\{C, A, B\}$ to deduce the triangular decouple upon to row permutation, provide some new results of the row by row decoupling, and associated pole assignment problems.

**This was a jointed work with Xuehan Cheng and Qian Wang.**

# On cone of nonsymmetric positive semidefinite matrices

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In this talk, we are concerning with the cone of nonsymmetric positive semidefinite matrices (NS-psd). Firstly, we report basic properties of the geometry of the NS-psd cone and show that it is a hyperbolic but not homogeneous cone. Secondly, we prove that the NS-psd cone is a maximal convex subcone of $P_0$-matrix cone which is not convex. But the interior of the NS-psd cone is not a maximal convex subcone of $P$-matrix cone. As the byproducts, some new sufficient and necessary conditions for a nonsymmetric matrix to be positive semidefinite are given. Finally, we present some properties of metric projection onto the NS-psd cone.

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# Minimal Distances of Lie Theoretic Codes

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Linear codes with large minimal distances are important error correcting codes in information theory. Orthogonal codes have more applications in the other fields of mathematics. We introduce an infinite family of binary and ternary orthogonal codes arising from the representations of Lie algebras. In particular, the Weyl groups are used in calculating the minimal distances of these codes.

# On the Product of Finitely Many Quadratic Forms

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The multiplicative programming is a class of nonlinear optimization problems having a product of convex functions as an objective or a constraint, which have been extensively studied by using global optimization techniques. The multiplicative programming is not an 'easy' class of optimization problems. It is NP-hard in general. An important issue is what subclass of the problems can be computationally tractable (be able to be solved in polynomial time). More specifically, when the product of finitely many convex functions remains convex? Answering this question may help us identify the subclass of multiplicative programming which can be effectively solved by modern convex optimization methods. On the other hand, a closely related question is what is the Legendre-Fenchel transform of the product of convex functions? From the viewpoint of developing Fenchel duality method for multiplicative programming, addressing this question is also important. In the quadratic form cases, we are going to answer these questions. We develop a sufficient convexity condition for the product of finitely many quadratic froms, and also prove that an explicit formula for the Legendre-Fenchel transform of the product function can be derived. The computation effort of the transform is almost equal to the amount of finding a fixed point of certain mapping with a special structure. The formula for the transform derived here sheds some light on the computational complexity for the transform of the product function.

# Exact certification in global polynomial optimization via sums-of-squares of rational functions with rational coefficients

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We present a hybrid symbolic-numeric algorithm for certifying a polynomial or rational function with rational coefficients to be non-negative for all real values of the variables by computing a representation for it as a fraction of two polynomial sum-of-squares (SOS) with rational coefficients. Our new approach turns the earlier methods by Peyrl and Parrilo at SNC'07 and ours at ISSAC'08 both based on polynomial SOS, which do not always exist, into a universal algorithm for all inputs via Artin's theorem.

Furthermore, we scrutinize the all-important process of converting the numerical SOS numerators and denominators produced by block semidefinite programming into an exact rational identity. We improve on our own Newton iteration-based high precision refinement algorithm by compressing the initial Gram matrices and by deploying rational vector recovery aside from orthogonal projection. We successfully demonstrate our algorithm on 1. various exceptional SOS problems with necessary polynomial denominators from the literature and on 2. very large (thousands of variables) SOS lower bound certificates for Rump's model problem (up to $n = 18$, $factor\ degree = 17$).

**Joint work with *Erich Kaltofen*,*Bin Li* and *Zheng-feng Yang*(North Carolina State University, Google China, and East China Normal University)**

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# Brief Introduction about Lijiang and Shangri-La

## Lijiang

It is said there is a fairyland beneath the colorful clouds of southern China. A place blessed with fresh air, clear streams, breathtaking snow-capped mountains, and an undisturbed landscape inhabited by a friendly group of people. Life in this fairyland is so peaceful, a fairyland called Lijiang, located at the hub of Tibet, Yunnan and Sichuan provinces.

While the geographical position of Lijiang City is remote, it has the advantage of ensuring a pleasant year round climate and a wide variety of tourist resources in the 20,600 square kilometers area. The earliest recorded history of Lijiang can be traced back to the Warring States Period (476 BC-221 BC) but with the advent of the Tang Dynasty (618-907), the local economy reached a peak with the development of the Ancient Tea-Horse Road which made a great contribution to both commercial and cultural communication between Tibet, Sichuan and Yunnan provinces.

At present, Lijiang City is an attractive tourist destination in Yunnan Province that exercises jurisdiction over four counties and an Old Town District. Lijiang is the main region inhabited by Naxi Group, one of China's 55 minority ethnic groups. In its long history, the local residents have established their splendid Dongba Culture which has absorbed aspects of the culture of Tibet and the Central Plains along the middle and lower reaches of the Yellow River. The various souvenirs marked with these Dongba hieroglyphs are very popular with visitors from home and abroad.

Lijiang has the best preserved ancient town in China - the Old Town which has been listed in the World Cultural Heritages by UNESCO in 1997. The Old Town was once the center of Lijiang and continues to maintain the original flavor of the local lifestyle, the typical groups of buildings and the profound cultural heritage of the region. When wandering along Square Street or any other streets in the Old Town, you will be struck by the peaceful surroundings. From enjoying the sight of the setting sun from historic hotels to local farmsteads, there are many favorable things here for travelers. Naturally, there are a number of tour destinations to enhance your visit as well. Among them, the most famous is Mufu (Mu's Palace) which should not be missed during your trip.

Around Lijiang, there are a number of splendid natural beauty spots that will certainly astonish you. If you like to see superlative natural scenery, Jade Dragon Snow Mountain which provides a majestic backdrop to the Moon-Embracing Pavilion at Black Dragon Pond will fulfill your desire. For those seeking an exotic experience in Lijiang, a visit to the Mosuo People beside Lugu Lake is a must. They are called the last 'Kingdom of Women' on earth. If you would like to experience the local lifestyle, then come and participate in one or more of their various festivals that are held throughout the year.

Lijiang does not have a direct rail link and is reached by travelers by air or by coach. However, having got to Lijiang, visiting round and about is easy with the help of the city buses, taxis or for the more energetic by bicycle. However, please don't forget to save some time to walk in Lijiang. Along your way, you must visit some of the souvenir shops and taste some local dishes and snacks. At night, the famous bar street in the Old Town is really worth a visit. No matter where you go, you will find a harmonious combination of tradition and fashion in Lijiang City.

## Shangri-La

Shangri-La is the "Eden in dream". Since it first appeared in British novelist James Hilton's Lost Horizon in the 1939, it has been associated with the mystique of a place which could not possibly exist here on Earth. In Tibetan,Shangri-La means the "sun and moon in heart", an ideal home only found in heaven. There the lofty and continuous snowy mountains, endless grasslands, steep and grand gorges, azure lakes and the bucolic villages always leave a deep impression on visitors.

Located at point where Tibet, Sichuan and Yunnan all meet, Shangri-La County is administered by Diqing Tibetan Autonomous Prefecture, Yunnan Province. In the past, Shangri-La was called Zhongdian or "Jiantang" in Tibetan. In ancient times, it together with Batang (in Tibet) and Litang (in Sichuan) was the fiefdom of the three sons of a Tibetan King. In 2002, Zhongdian changed its name to Shangri-La.

At an average altitude of more than 3,000 meters (about 9,843 feet), Shangri-La is very difficult to reach. Without railways leading there, the chief means of transportation is motor vehicles. To get there, tourists will typically begin their journey in Kunming, traveling first to Lijiang and then taking the long-distance bus in Lijiang to Shangri-La. It's about 175 kilometers (108.74 miles) from Lijiang to Shangri-La. On this way, the Tiger Leaping Gorge can be seen.

Shangri-La is inhabited by many different ethnic groups, with the Tibetans comprising the majority of the population. There you will have an opportunity to experience Tibetan life and learn about their lifestyle, religion and cuisine. The unique scenery, highlighted by plateaus, together with the fascinating ethnic culture makes Shangri-La very attractive and charming to visit.

Shangri-La is rich in natural resources from valuable herbs to rich mineral deposits (including gold, silver, copper, manganese and many other rare metals) to abundant animal resources (such as golden monkeys, leopards and musk deer). Shangri-La is a land full of natural wonders.

As a Chinese saying goes, "The earliest sunrise is seen in Shangri-La; and the most unique place is also there". Once you visit, you will fully appreciate the meaning of this saying. In addition, the warm welcome of the residents of this land will make you feel at home.

*The organizing committee wishes you a pleasant stay in Lijiang!*