International Conference on Numerical Analysis, Approximation and Optimization

Dedicated to late Professor M.J.D. Powell

August 5–7, 2016

Beijing, China

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

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Information for Participants

Conference Hotel and Conference Venue

Hotel: Liaoning Hotel, Beijing

辽宁大厦

Address: No. 2 A North 4th Ring Road West, Haidian District, Beijing

北京市海淀区北四环西路甲2号

Venue: Room 204, The South Building of Academy of Mathematics and Systems Science, CAS

中国科学院数学与系统科学研究院南楼204室

Address: No. 55, Zhong Guan Cun East Road, Haidian District, Beijing

北京市海淀区中关村东路55号

On-site Registration

On-site registration will take place at the **lobby of Liaoning Hotel, Beijing** on **August 4** from **14:00** to **20:00**. You can also register at any other time during the conference, but please contact Prof. Xin Liu or Dr. Ying Liu in advance.

Currency

Chinese currency is RMB. The current rate is about 6.69 RMB for 1 US dollar. The exchange of foreign currency can be done at the airport or the banks in Beijing, but some additional processing fee will be charged. 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.

Internet

WIFI is available in the conference room. Please follow the instructions below:

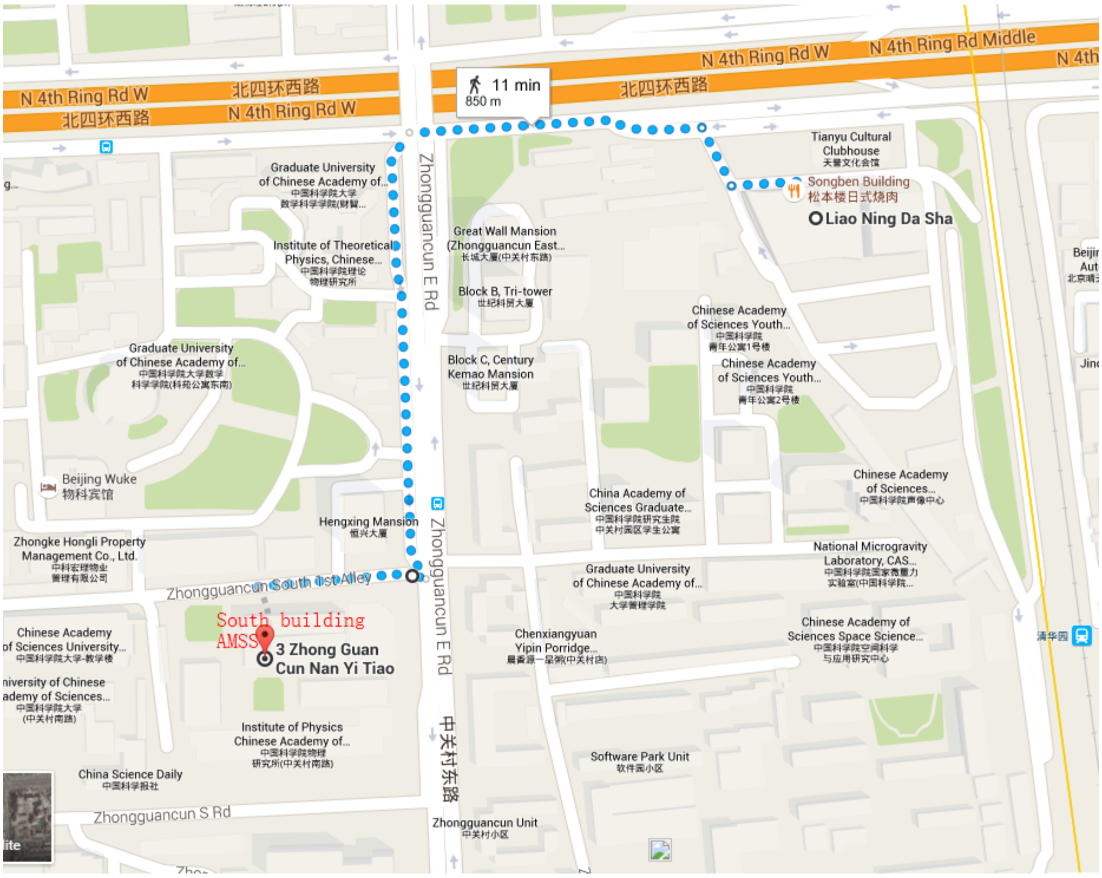
- connect to the WIFI network "AMSS";
- your browser will be directed to a request form at your first attempt to visit the internet;
- input the workshop code "P1N8P8N4" into the first blank cell;
- click the "submit" button, and you will get connected.

Contact Information

If you need any help, please feel free to contact

- Prof. Xin Liu: +86-138-1000-2122
- Dr. Ying Liu: +86-138-1080-6086

The route from hotel to venue



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- Institute of Computational Mathematics and Scientific/Engineering Computing, AMSS, CAS
- State Key Laboratory of Scientific and Engineering Computing
- National Natural Science Foundation of China
- Chinese Mathematical Society
- Center for Optimization and Applications, AMSS, CAS

Organizing Committee

Conference Chair

- Ya-xiang Yuan (Chinese Academy of Sciences, China)

Committee Members

- Martin Buhmann (University of Giessen, Germany)
- Coralia Cartis (Oxford University, UK)
- Yu-Hong Dai (Chinese Academy of Sciences, China)
- Xin Liu (Chinese Academy of Sciences, China)
- Philippe Toint (The University of Namur, Belgium)
- Zaiwen Wen (Peking University, China)

Honored Guests

- Caroline Powell
- Catherine Powell
- Alice Powell

Invited Speakers

- Hermann Brunner (Hong Kong Baptist University)
- Martin Buhmann (University of Giessen, Germany)
- Andrew Conn (IBM Watson Center, USA)
- Ioannis Demetriou (University of Athens, Greece)
- David Gay (AMPL Optimization, USA)
- Arieh Iserles (Cambridge University, UK)
- Jorge Moré (Argonne National Laboratory, USA)
- Marc Teboulle (Tel Aviv University, Israel)
- Philippe Toint (The University of Namur, Belgium)

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Conference Schedule

August 5, Friday

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 Arieh Iserles**, Fast Computation of an Expansion into Hermite Functions

10:20–10:40 Coffee Break

10:40–12:00 Invited Talks V2
Chair: Arieh Iserles

- **10:40–11:20 Marc Teboulle**, Performance of First Order Methods for Convex Minimization: A Novel Approach
- **11:20–12:00 Mengdi Wang**, Online Value-Policy Iteration for Reinforcement Learning

12:00–14:00 Lunch

14:00–16:00 Memorial Session for Roger Fletcher M1
Chair: Chengxian Xu

- **14:00–14:40 Philippe Toint**, Filter Methods: A Tribute to Roger Fletcher

14:40–15:20 **Fengmin Xu**, Sparse Optimization Models and Methods with Applications in Finance

15:20–16:00 **Yu-Hong Dai**, The Steepest Descent and Conjugate Gradient Methods Revisited

16:00–16:20 Coffee Break

16:20–17:40 Memorial Session for Roger Fletcher M2

Chair: Yu-Hong Dai

16:20–16:40 **Chungen Shen**, A Filter Active-set Algorithm for Ball/Sphere Constrained Optimization Problem

16:40–17:00 **Chengyi Zhang**, Generalizations of the Geršgorin Circle Theorem and Block H-tensors

17:00–17:20 **Bo Jiang**, Stochastic Gradient Descent Methods for Optimization with Orthogonality Constraints and Beyond

17:20–17:40 **Chengxian Xu**, In Memory of late Professor Roger Fletcher

18:00–20:00 Dinner

August 6, Saturday

09:00–10:20 Invited Talks V3

Chair: Philippe Toint

09:00–09:40 **Jorge Moré**, Computational Noise: Uncertainty in Computational Science

09:40–10:20 **David Gay**, Revisiting Function, Gradient, and Hessian Computations for Nonlinear AMPL Models

10:20–10:40 Coffee Break

10:40–12:00 Invited Talks V4

Chair: Ioannis Demetriou

10:40–11:20 **Hermann Brunner**, On the Convergence of Projection Methods for Volterra Integral Equations

11:20–12:00 **Martin Buhmann**, Mike Powell's Work on Approximation Theory

12:00–14:00 Lunch

14:00–15:40 Contributed Talks C1
Chair: Zaiwen Wen

14:00–14:20 **Zaikun Zhang**, NEWUOAs: A Derivative-free Optimization Algorithm Based on Powell's NEWUOA and Subspace Techniques

14:20–14:40 **Yafeng Liu**, On the Non-ergodic Convergence Rate of an Inexact Augmented Lagrangian Framework for Composite Convex Programming

14:40–15:00 **Cong Sun**, On a Special Structured Matrix Problem

15:00–15:20 **Qingna Li**, A Euclidean Distance Matrix Based Model for Ordinal Embedding

15:20–15:40 **Jiang Hu**, Adaptive Regularized Method for Optimization on Riemannian Manifold

15:40–16:00 Coffee Break

16:00–17:20 Contributed Talks C2
Chair: Xin Liu

16:00–16:20 **Xinlong Luo**, Localization Error Analysis of RFPM Method Based on Truncated Gaussian Models

16:20–16:40 **Yishuai Niu**, Recent Advances in DC Programming and DC Algorithms for General DC Program

16:40–17:00 **Congpei An**, A Quick Numerical Trip to Spherical t-designs

17:00–17:20 **Leqin Wu**, Variable Selection in a System of Differential Equations

17:20–17:40 **Qian Dong**, A Parallel Line Search Subspace Correction Method for Composite Convex Optimization

18:00–20:00 Conference Banquet

August 7, Sunday

09:00–10:20 Invited Talks V5

Chair: Martin Buhmann

09:00–09:40 **Ioannis Demetriou**, A Binary Tree Algorithm for Least Squares Piecewise Monotonic Data Approximation

09:40–10:20 **Philippe Toint**, High-order Optimality in Nonlinear Optimization: Necessary Conditions and a Conceptual Approach of Evaluation Complexity

10:20–10:40 Coffee Break

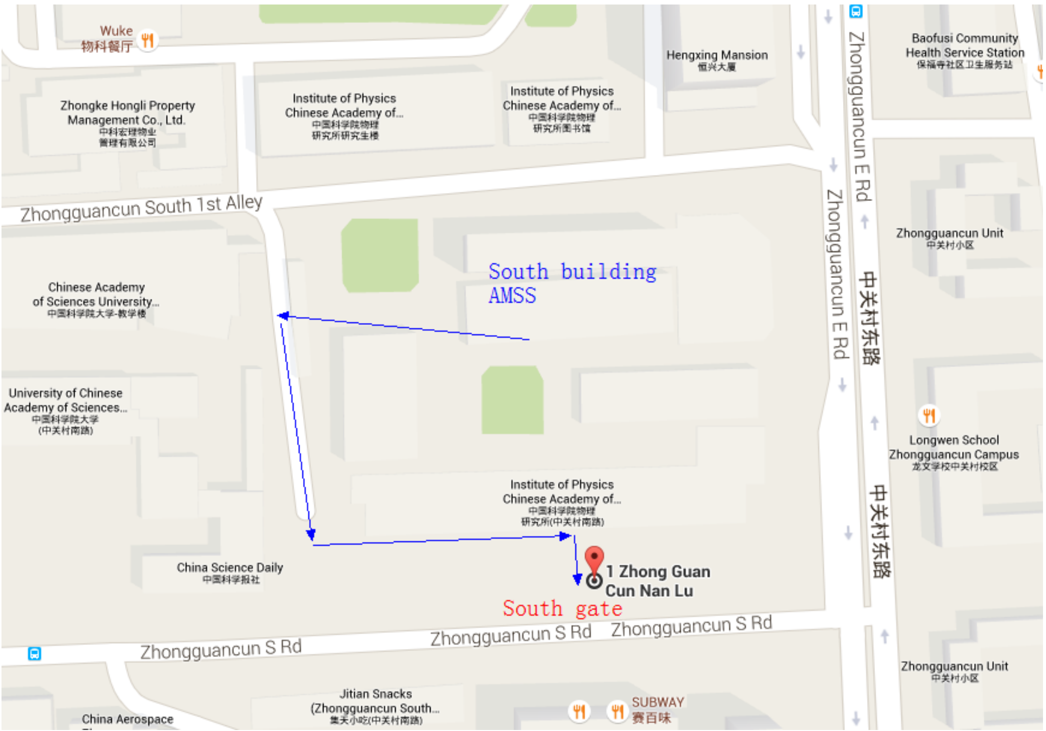
10:40–11:00 Close Ceremony

11:00–11:40 Lunch

12:00– Excursion: The Summer Palace

Note

The bus to the Summer Palace will depart from the south gate of Institute of Physics at 12:00. The route from AMSS to the rally point is given below.



Abstracts

Part I

Invited Talks

On the Convergence of Projection Methods for Volterra Integral Equations

Hermann Brunner

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The convergence of collocation methods in piecewise polynomial spaces for Volterra integral equations of the first and second kind has been studied extensively and is now quite well understood. There are, perhaps surprisingly, still a number of questions that have not yet been answered. They concern finding necessary and sufficient conditions for the collocation points so that the collocation solution converges uniformly to the solution of the given Volterra integral equation. Of particular interest are Volterra integral equations with kernel singularities, Volterra functional integral equation with certain delay arguments, and (cordial) Volterra integral equations corresponding to non-compact integral operators. Since fully discretized (continuous or discontinuous) Galerkin methods are closely related to collocation methods, the answers to these questions will be crucial for the complete understanding of the convergence of these variational methods.

Mike Powell's Work on Approximation Theory

Martin Buhmann

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Like in optimisation, Mike Powell was a giant in approximation theory too. Among very many other things, he contributed greatly in splines, radial basis functions, rational approximation, finite elements etc, all with respect to theory and algorithms. This of course includes his excellent book on Approximation Theory & Methods. We will summarise several of his results to give some insight into his numerous contributions.

Resolving Aircraft Conflicts by Continuous Optimization and Mixed-Integer Nonlinear Programming

Andrew Conn

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Detection and resolution of aircraft conflicts in en-route flights controls the separation (typically set at 5 Nautical Miles) between aircraft trajectories. It is crucial to ensure flight safety and remains a challenging problem in Air Traffic Management . Taking into account the increasing air traffic worldwide and its impact on air traffic controllers' workload, a higher level of automation is urgently needed. In the present work, we propose two novel optimization formulations, where the decisions include both aircraft speed and heading angle changes. Both formulations exploit the removal of the infinite-dimensional feature of the separation constraint and rely on a linearisation of angle-related nonlinear terms. The first formulation is based on Mixed-Integer Nonlinear Programming and enables the simultaneous consideration of continuous variables (aircraft speeds, heading angles, etc.) as well as integer ones (to model logical choices, and the inherently combinatorial pairwise nonlinear separation constraints). The second formulation we propose is a purely continuous optimization model, where we introduce an exact l1-penalty function, tailored to the problem at hand, to deal with the aircraft separation constraints. A variant of the introduced models that aims at increasing the aircraft separation distance, results in robust solutions for air traffic controllers. Numerical results on a set of problem instances validate the approaches while highlighting the versatility of the proposed models.

Joint work with Sonia Cafieri and Marcel Mongeau, École nationale de l'aviation civile (ENAC), Toulouse, France

A Binary Tree Algorithm for Least Squares Piecewise Monotonic Data Approximation

Ioannis Demetriou

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Piecewise monotonic approximation makes the least sum of squares change to n noisy measurements of a univariate function, so that the first divided differences of the smoothed values have at most $k-1$ sign changes, where k is a prescribed positive integer. The approximated values form a n-vector with k monotonic sections in its components, alternately increasing and decreasing. The positions of the joins of the sections, namely the local extrema of the fit, are integer variables of the optimization process, which raises the number of combinations to $O(n^{k-1})$. For example, if $n = 200$, $k = 5$ and the data are the values ± 1 changed by an amount ε, then the problem may have 4 082 925 possibilities of combinations of extrema to finding an optimal one. Our method solves this problem in less than 15 000 computer operations. To be specific, a fast algorithm is developed that partitions the data into at most k disjoint sets of adjacent data and solves a monotonic approximation problem for each set. By taking advantage of certain properties of the extrema and a tree data structure that are implied by the optimization calculation, the partition is carried out by a dynamic programming procedure, which is implemented in $\log_2 n$ levels of bisection of the data to obtain an extremum, a process that is repeated $k-1$ times to derive an optimal approximation with $k-1$ extrema. The total work is only $O(n^2 + kn\log_2 n)$ computer operations when $k \geq 3$. Fortran software has been written by the author that can manage efficiently very many thousands of data and some of its numerical results will be given. This approximation calculation may have many applications. For

example, it is highly suitable in estimating turning points (peaks) of a function from some measurements of its values which are distorted by random errors. Peak finding is a subject of continuous interest in spectroscopy, chromatography and signal processing, for instance. Other examples arise from medical imaging, i.e. in reducing the noise in magnetic resonance imaging and computed tomography, as well as in achieving shorter processing times in multiple serial examinations of the same data.

Revisiting Function, Gradient, and Hessian Computations for Nonlinear AMPL Models

David Gay

AMPL Optimization

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AMPL facilitates stating and solving nonlinear programming problems involving algebraically defined objectives and constraints, including complementarity conditions. For solving such problems, the AMPL/solver interface library provides routines that compute objective functions, constraint residuals, gradients, Hessian-vector products and explicit Hessian matrices. Objectives and constraint bodies hitherto have been represented by "executable" expression graphs, in which each node points to its operands and to a function that computes the node's result. Nodes also store partial derivatives for use in computing gradients and Hessians by automatic differentiation. Storing these values makes the graphs nonreentrant. To allow several threads to evaluate the same expression at different points without having separate copies of the expression graphs, such details as variable values and partial derivatives must be stored in thread-specific arrays. We describe and compare some ways to represent and use expression graphs in these computations.

Fast Computation of an Expansion into Hermite Functions

Arieh Iserles

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Many partial differential equations of interest are conveniently stated as a Cauchy problem. This is true in particular with regards to equations of quantum mechanics. There are important advantages in solving them with spectral methods, yet such methods are predicated on the availability of fast (i.e. O(n log n)) expansions. The most enticing possibility is to use a basis of Hermite functions, because they lead to a tridiagonal, skew-symmetric differentiation matrix, thereby ensuring numerical stability, ensuring conservation of energy and leading to fast computation of time steps.

The challenge is this to expand fast in Hermite functions and this is the theme of this talk. Assuming sufficiently rapid decay of a sufficiently 'nice' function at infinity, we first prove the Sombrero Theorem: essentially, even though the function is not periodic, the Fourier coefficients of sufficiently stretched function decay spectrally until they are very small (typically, much smaller than required accuracy), whereby they assume the expected, exceedingly slow decay. (In logarithmic scale we obtain an outline of a sombrero, hence the name.) Of course, these coefficients can be computed by FFT in O(n log n) operations. We subsequently use connection coefficients to compute the coefficients in a Hermite function expansion in additional O(n) operations.

This is joint work with Helge Dietert.

Computational Noise: Uncertainty in Computational Science

Jorge Moré

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The reliability of algorithms has been an important research topic for at least fifty years, but new issues arise as algorithms and computational environments evolve. In this talk we survey these issues and show that the reliability of algorithms can be analyzed in terms of computational noise.

We define computational noise for a function (or simulation) in a probabilistic setting, and show how computational noise arises in large-scale calculations, iterative and adaptive algorithms, and mixed-precision calculations. We outline the ECnoise algorithm for computing the noise level of a function, and show that ECnoise produces reliable results at a cost of six function evaluations.

We discuss how computational noise destroys the accuracy of calculations, even those that require a few (less than 100) flops and have no cancellation errors. We also show that the noise level can be used to obtain near-optimal estimates of the derivative of a function.

Performance of First Order Methods for Convex Minimization: A Novel Approach

Marc Teboulle

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We introduce a novel approach for analyzing the worst-case performance of first-order black-box convex optimization methods. Our approach relies on the observation that by definition, the worst-case behavior of an optimization method is by itself an optimization problem which consists of finding the maximal abolute inacurracy over all possible inputs of the algorithm, and which we call the performance estimation problem (PEP). This is an abstract and challenging optimization problem in infinite dimension which appears to be untractable. We present a methodology to design and analyze the PEP for a broad class of first order black-box algorithms. It allows to derive new and improved complexity bounds for the gradient method, the heavy-ball method and the fast gradient schemes. We also derive an efficient procedure for finding optimal step sizes which results in a first-order black-box method that achieves best worst-case performance. This is joint work with Yoel Drori.

High-order Optimality in Nonlinear Optimization: Necessary Conditions and a Conceptual Approach of Evaluation Complexity

Philippe Toint

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Optimality conditions for high-order criticality (orders 2 and beyond) for convexly constrained nonlinear optimization will be discussed, as well as some intrinsic difficulties arising in this context. A specific approach using Taylor series will be introduced, which naturally leads to a trust-region-like conceptual algorithm. The evaluation complexity of this algorithm will then be analyzed, providing the first arbitrary-order optimality evaluation complexity bounds for convexly constrained optimization. The consequences of this new bound on the solution of constrained problems will also be analyzed, yielding the an evaluation complexity bound for general nonlinear optimization. The limitations of this latter approach will finally be discussed.

Online Value-Policy Iteration for Reinforcement Learning

Mengdi Wang

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We consider the online solution of discounted Markovian decision process (MDP). We focus on the black-box model where transition probabilities and state transition cost are unknown. Instead, a simulator is available to generate random state transitions under given actions. We propose a stochastic primal-dual algorithm for solving the linear formulation of the Bellman equation. The algorithm updates the primal and dual iterates by using sample state transitions and sample costs generated by the simulator. We show that the t -th averaged dual iterate can be implemented as a near-optimal randomized policy, achieving an eciency loss of the order 1/sqrt(t). Moreover, we provide a thresholding procedure that recovers the exact optimal policy from the dual iterates with high probability.

Part II

Memorial Session Talks

The Steepest Descent and Conjugate Gradient Methods Revisited

Yu-Hong Dai

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The steepest descent and conjugate gradient methods are basic first order methods for unconstrained optimization. More efficient variants have been proposed in recent decades by forcing them to approximate Newton's method (or quasi-Newton method). In this talk, I shall review some recent advances on steepest descent method and conjugate gradient method. While significant numerical improvements have been made, the behavior of these more efficient variants are still to be understood and more analysis are obviously required.

Stochastic Gradient Descent Methods for Optimization with Orthogonality Constraints and Beyond

Bo Jiang

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We mainly consider feasible variance reduced gradient (F-SVRG) methods for minimizing a finite-sum function with orthogonality constraints. The iteration complexity for achieving an ϵ-stationary point in expectation is established as $O(n^{\frac{2}{3}}/\epsilon)$, where n is the number of component functions. The linear convergence of F-SVRG is also discussed. We also propose a F-SVRG-BB method that adopts Barzilai-Borwein step. Some preliminary numerical results are presented to show the efficiency of the proposed methods. Besides, some extensions of F-SVRG to more general manifolds are also investigated.

A Filter Active-set Algorithm for Ball/Sphere Constrained Optimization Problem

Chungen Shen

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In this talk, we introduce a filter active-set algorithm for the minimization problem over a product of multiple ball/sphere constraints. By making effective use of the special structure of the ball/sphere constraints, a new limited memory BFGS (L-BFGS) scheme is presented. Filter technique combining with the backtracking line search strategy ensures the global convergence, and the local superlinear convergence can also be established under mild conditions. Our numerical experiments indicate that the proposed algorithm is competitive to some recently methods.

Filter Methods: A Tribute to Roger Fletcher

Philippe Toint

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The talk will (re)-introduce the basic ideas of the class of filter methods, due to Fletcher and Leyffer. The use of the central idea of non-domination will be presented both for unconstrained and general constrained problems. Some numerical results will also be shown that confirm the excellent performance of this approach in practice. The talk is dedicated to Roger Fletcher, a major figure in mathematical optimization.

Sparse Optimization Models and Methods with Applications in Finance

Fengmin Xu

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In the practical business environment, portfolio managers often face business driven requirements that limit the number of constituents in their optimal portfolio. A natural sparse Finance optimization model is thus to minimize a given objective function while enforcing an upper bound on the number of assets in the portfolio. In this talk we consider three kinds of sparse finance optimization problem, including sparse portfolio selection, sparse index tracking and sparse portfolio rebalancing. In particular, we propose an efficient method for solving these problem. Under some suitable assumptions, we establish that any accumulation point of the sequence generated by our method is a local minimizer of these sparse Finance optimization problems. We also conduct empirical tests to demonstrate that our approach generally produces sparse portfolios with higher out-of-sample performance.

Generalizations of the Geršgorin Circle Theorem and Block H-tensors

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In this report, Geršgorin theorem of block matrices proposed by David G. Feingold and Richard S. Varga (see, David G. Feingold and Richard S. Varga, Block diagonally dominant matrices and generalizations of the Geršgorin circle theorem, Pacific Journal of Mathematics, 12(4): 1241-1250) is extended to block tensors such that the location and distribution of H-eigenvalues of block tensors are derived to proposed some significant results including the judgment of symmetric positive definite tensors. In what follows, the concepts of block diagonally dominant tensors and bock H-tensors are defined and some properties on H-eigenvalue of these block tensors are proposed.

Part III

Contributed Talks

A Quick Numerical Trip to Spherical t-designs

Congpei An
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We draw our attention on the unit sphere in three dimensional Euclidean space. A set X_N of N points on the unit sphere is a spherical t-design if the average value of any polynomial of degree at most t over X_N is equal to the average value of the polynomial over the sphere. The last forty years have witnessed prosperous developments in theory and applications of spherical t-designs. Let integer $t > 0$ be given. The most important question is how to construct a spherical t-design by minimal N. It is commonly conjectured that $N = \frac{1}{2}t^2 + o(t^2)$ point exists, but there is no proof. In this talk, we firstly review recent results on numerical construction of spherical t-designs by various of methods: nonlinear equations/interval analysis, variational characterization, nonlinear least squares, optimization on Riemanninan manifolds. Consequently, results on numerical integration over the sphere by using spherical t-designs are also discussed.

A Parallel Line Search Subspace Correction Method for Composite Convex Optimization

Qian Dong

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We investigate a parallel subspace correction framework for composite convex optimization based domain decomposition method. At each iteration, the algorithms solve subproblems on subspaces simultaneously to construct a search direction and take the Armijo line search to find a new point. They are called PSCLN and PSCLO, respectively, depending on whether there are overlapping variables. Their convergence is established under mild assumptions. We compare them with state-of-the-art algorithms for solving LASSO problems, which shows that PSCLN and PSCLO can run fast and return solutions no worse than those from the others. It is also observed that the overlapping scheme is helpful for the structured-data problem.

Adaptive Regularized Method for Optimization on Riemannian Manifold

Jiang Hu

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Optimization on Riemannian manifold widely arises in eigenvalue computation, density functional theory, Bose-Einstein condensates, image and signal processing. We propose a second-order type approximation to the original problem and apply a first-order type method to solve it. Global convergence to the first-order optimality conditions is established. Preliminary numerical experiments show that our method is promising.

A Euclidean Distance Matrix Based Model for Ordinal Embedding

Qingna Li

Beijing Institute of Technology

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Ordinal embedding is a classical statistic topic, and has been widely used as a way of data analysis in machine learning. It is to embed objects into a lower dimensional space, such that the order of the distances between objects can be kept as much as possible. The large scale of data brings great challenge to the traditional model and algorithms. In this talk, we propose a Euclidean distance matrix based model for ordinal embedding, and the ordinal constraints are presented as linear inequality constraints. An inexact smoothing Newton method is applied to solve the dual problem of the relaxed convex model. To tackle the large scale of the ordinal constraints, we propose a practical scheme that can selectively choose the ordinal constraints, and therefore, reduce the size of dual problem significantly. Numerical results demonstrate the efficiency of the proposed model and scheme.

On the Non-ergodic Convergence Rate of an Inexact Augmented Lagrangian Framework for Composite Convex Programming

Yafeng Liu

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In this talk, we consider the linearly constrained composite convex optimization problem, whose objective is a sum of a smooth function and a possibly nonsmooth function. We propose an inexact augmented Lagrangian (IAL) framework for solving the problem. The proposed IAL framework requires solving the augmented Lagrangian (AL) subproblem at each iteration less accurately than most of the existing IAL frameworks/methods. We analyze the global convergence and the non-ergodic convergence rate of the proposed IAL framework.

This is a joint work with Xin Liu at CAS and Shiqian Ma at CUHK.

Localization Error Analysis of RFPM Method Based on Truncated Gaussian Models

Xinlong Luo

Beijing University of Posts and Telecommunications

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In this talk, we will introduce a wireless network localization technology based on the received signal strength indications (RSSI), which are reported to the base stations from user equipments. The localization method is based on the principle of radio frequency patten matching (RFPM) of truncated Gaussian models. An analysis of the localization lower bound is also given.

Recent Advances in DC Programming and DC Algorithms for General DC Program

Yishuai Niu

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We will present the state of the Art in recent advances of DC (Difference of Convex functions) Programming and DCA (DC Algorithms). After a brief summary of basic theoretical and algorithmic results in DC programming and DCA, we will outline some new results on: 1. Exact penalty techniques with/without error bounds in DC programming (including mixed integer DC programming); 2. DC Algorithm for general DC programs involving DC constraints.

On a Special Structured Matrix Problem

Cong Sun

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A special matrix problem is considered from the application in wireless communications. The dimensions of the variables are optimized along with the variables. First, we prove that the problem is NP-hard. Then, we approximate the objective function by a fraction function. By applying the alternating minimization method, we conclude the subproblem as a 0-1 quadratic programming. Efficient algorithms are proposed to solve the problem. Simulations show the good performances of our proposed algorithms.

Variable Selection in a System of Differential Equations

Leqin Wu

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Variable selection problem is a problem which concentrates on fathoming the sparsity structure of a system via observation data. In this talk, we will mainly discuss a large-scaled system of differential equations. We will introduce the optimization model, algorithm to efficiently solve it, and finally several applications.

NEWUOAs: A Derivative-free Optimization Algorithm Based on Powell's NEWUOA and Subspace Techniques

Zaikun Zhang

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We discuss how to incorporate subspace techniques into algorithms that do not use derivatives, and present NEWUOAs, a derivative-free unconstrained optimization algorithm that minimizes the objective function in a sequence of subspaces. In each iteration, NEWUOAs determines a low-dimensional subspace based on a quadratic model of the objective function, and then minimizes the objective function in this subspace using the NEWUOA method by Powell. The new algorithm works evidently better than NEWUOA on a group of test problems with hundreds of variables. Moreover, it is capable of solving many 2000-dimensional test problems within several minutes using not more than 50000 function evaluations, which is equivalent to less than 25 simplex gradients.

We also show a simple extension of NEWUOAs to handle bound constraints, and compare the resulting algorithm with Powell's BOBYQA.

List of Participants of ICNAAO

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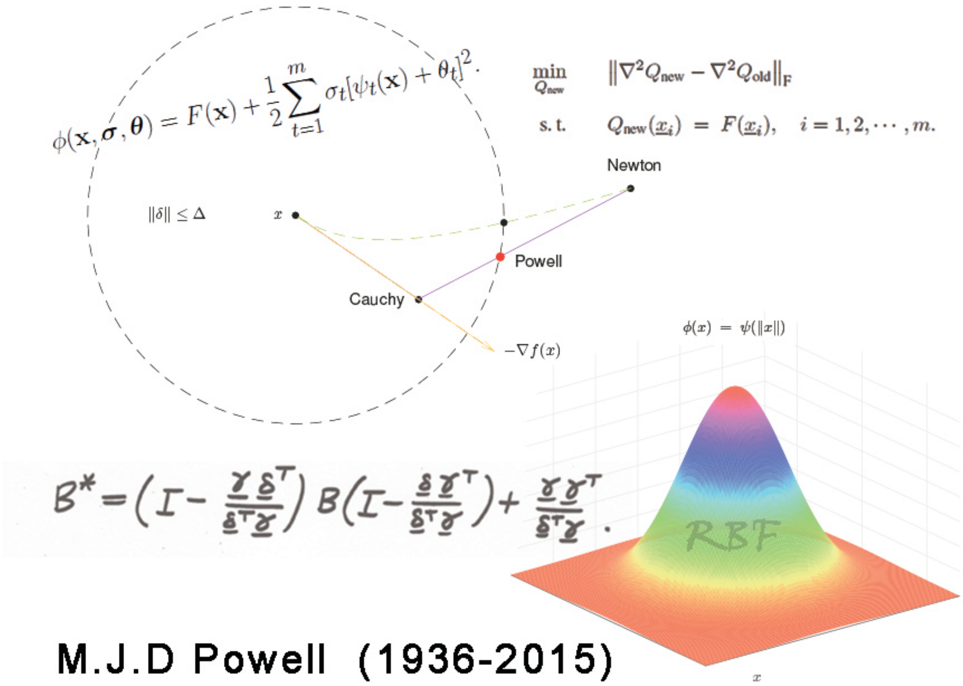
Excursion: The Summer Palace[1]

The Summer Palace (Chinese: 颐和园; pinyin: Yíhéyuán), is a vast ensemble of lakes, gardens and palaces in Beijing, China. It serves as a popular tourist destination and recreational park. Mainly dominated by Longevity Hill (万寿山; Wànshòu Shān) and Kunming Lake (昆明湖; Kūnmíng Hú), it covers an expanse of 2.9 square kilometres, three-quarters of which is water.

Longevity Hill is about 60 metres (200 feet) high and has many buildings positioned in sequence. The front hill is rich with splendid halls and pavilions, while the back hill, in sharp contrast, is quiet with natural beauty. The central Kunming Lake, covering 2.2 square kilometres (540 acres), was entirely man-made and the excavated soil was used to build Longevity Hill.

In December 1998, UNESCO included the Summer Palace on its World Heritage List. It declared the Summer Palace "a masterpiece of Chinese landscape garden design. The natural landscape of hills and open water is combined with artificial features such as pavilions, halls, palaces, temples and bridges to form a harmonious ensemble of outstanding aesthetic value".

[1] From wikipedia: https://en.wikipedia.org/wiki/Summer_Palace.



M.J.D Powell (1936-2015)