Workshop on Scientific Computing and Matrix Analysis

On the occasion of the tenth anniversary of Macao handover

University of Macau
Macao, P. R. China
Date: 28 – 30th, December 2009

Hotel:
New Century Hotel (新世纪酒店)
http://www.newcenturyhotel-macau.com

Venue:
Room HG01
Ho Yin Convention Centre （何贤会议中心）
University of Macau
http://www.umac.mo/docs/UM_campus_map.pdf (**H** building in the map)

Scientific Committee:
Raymond H. Chan, Chinese University of Hong Kong
Zhong-ci Shi, Chinese Academy of Sciences
Xiao-qing Jin, University of Macau
Michael K. Ng, Hong Kong Baptist University
Fu-rong Lin, Shantou University
Hai-wei Sun, University of Macau

Local Organizers:
Xiao-qing Jin (Chair)
Hai-wei Sun (Secretary)
Deng Ding
Che-man Cheng
Vai-kuong Sin
Seak-weng Vong
Siu-long Lei

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December 28, Monday Evening
Registration and reception

December 29, Tuesday

8:45-8:55	**Opening Ceremony**
8:55-9:00	**Group photo**
	Session I (Chair: Che-man Cheng)
9:00-9:30	**Zhong-ci Shi** Cascadic Multigrid Methods
9:30-10:00	**Raymond H. Chan** Maximum Entropy Principle for Composition Vector Method in Phylogeny
10:00-10:30	**San-zheng Qiao** A Lattice Basis Reduction Method
10:30-10:50	Break
	Section II (Chair: Zhong-ci Shi)
10:50-11:20	**Wen Li** The Numerical Analysis for the Saddle Point Systems
11:20-11:50	**Yi-min Wei** Super-Large Sparse Matrix Computations in Web Information Retrieval
11:50-12:20	**Zheng-jian Bai** Some Optimization Approaches for Robust and Minimization Norm Partial Quadratic Eigenvalue Assignment in Vibrating Systems
12:20-14:30	**Lunch** (Kapok Cantonese Restaurant, 六棉酒家)
	Section III (Chair: Raymond H. Chan)
14:30-15:00	**Fu-rong Lin** Highly Accurate Numerical Solution Methods for Fredholm Integral Equation of the Second Kind with Semi-Smooth Kernel
15:00-15:30	**Wai-ki Ching** On Construction of Probabilistic Boolean Networks
15:30-16:00	**Man-chun Yeung** Breakdown analysis of Krylov subspace methods
16:00-16:20	Break
	Section IV (Chair: Wai-ki Ching)
16:20-16:50	**Andy M. Yip** Document Restoration Using Inpainting and Shape-from-Shading
16:50-17:20	**You-wei Wen** A Fast Splitting Algorithm for Multi-Frame Total Variation Blind Video Deconvolution
17:20-17:50	**Hong-kui Pang** Quadratic Finite Element with Preconditioning for Options Pricing in Stochastic Volatility Jump-Diffusion Models
18:30-22:00	**Banquet in Macau Tower**

December 30, Wednesday

	Section V (Chair: San-zheng Qiao)
8:30-9:00	**Yu-mei Huang** A New Total Variation Method for Multiplicative Noise Removal
9:00-9:30	**Shu-qin Zhang** Optimal Control Policy for Probabilistic Boolean Networks with Hard Constraints
9:30-10:00	**Li-ping Jing** A Novel Framework with Compressed Sensing for Stable Gene Selection in Cancer Prediction
10:00-10:30	**Kin-sio Fong** Another Proof for Commutators with Maximal Frobenius Norm
10:30-10:50	Break
	Section VI (Chair: Xiao-qing Jin)
10:50-11:20	**Chi-pan Tam** Fast Nonconvex Nonsmooth Minimization Method for Image Restoration and Reconstruction
11:20-11:50	**Hai-yong Liao** On Selection of Regularization Parameter in Total Variation Image Restoration
11:50-12:20	**Spike T. Lee** Shift-Invert Arnoldi Approximation to the Toeplitz Matrix Exponential
	Conclusion Remark
12:20-12:40	**Xiao-qing Jin** A speech on TOTS history
12:40-13:00	Other closing speech
13:00-14:30	**Lunch** (Kapok Cantonese Restaurant, 六棉酒家)
14:30	**Free activity, closed the workshop**

Cascadic Multigrid Methods

Zhong-ci Shi
Institute of Computational Mathematics, Chinese Academy of Sciences

Abstract

Multigrid method is supposed to be the one of most efficient methods for solving large scale linear system of N unknowns with O(N) computational complexity. There are mainly two types of multigrids: W-cycle that uses two corrections in each cycle, and V-cycle that uses only one correction per cycle. Recently (1996--) there appears a new type of multi grids, the so-called Cascadic Multigrid which uses NO correction at all, but only a number of iterations on each level of grids. So it can be viewed as a one-way multigrid. We have established a general framework of the cascadic multigrid method and given a detailed convergence analysis of this new method in conjunction with its applications for the finite element approximation of the second as well as the fourth order elliptic partial differential equations. Meanwhile, we have proposed a new technique on the determination of iteration numbers on each level which can greatly reduce the computational costs in the whole process.

Maximum Entropy Principle for Composition Vector Method in Phylogeny

Raymond H. Chan
Department of Mathematics, Chinese University of Hong Kong

Abstract

The composition vector (CV) method is an alignment-free method for phylogeny. Since the phylogenetic signals in the biological data are often obscured by noise and bias, denoising is necessary when using the CV method. Recently a number of denoising formulas have been proposed and found to be successful in phylogenetic analysis of bacteria, viruses etc. By using the maximum entropy principle for denoising and utilizing the structure of the constraint matrix to simplify the optimization, we derive several new formulas. With these formulas, we obtain a phylogenetic tree which identifies correct relationships between different gerera of Archaea strains in family Halobacteriaceae by using the 16S rRNA dataset; and also a phylogenetic tree which correctly groups birds and reptiles together, and then Mammals and Amphibians successively by using the 18S rRNA dataset.

A Lattice Basis Reduction Method

San-zheng Qiao
Department of Computing and Software, McMaster University

Abstract

After an introduction to lattice and basis, wepresent a lattice basis reduction method that computes a Minkowski-reduced basis from a given basis for a lattice. Then, we compare our method with the currently widely used LLL lattice basis reduction algorithm.

The Numerical Analysis for the Saddle Point Systems

Wen Li
School of Mathematical Sciences, South China Normal University

Abstract
In this talk we give some solvers for saddle point systems, also we present the perturbation analysis and the backward error analysis for this system.

Super-Large Sparse Matrix Computations in Web Information Retrieval

Yi-min Wei
School of Mathematical Sciences, Fudan University

Abstract
In this talk, we will introduce Mathematical background of the PageRank problem, A Power-Arnoldi algorithm for PageRank, Arnoldi vs. GMRES for the PageRank problem and On Jordan canonical form of the Google matrix. Application to the analysis of microarray data mining is also presented.

Breakdown Analysis of Krylov Subspace Methods.

Man-chun Yeung
Department of Mathematics, University of Wyoming

Abstract
Krylov subspace methods are popular iterative methods in the real-world computation due to their cheap memory requirement and computational cost. Theoretically, a breakdown of a Krylov method can happen when a zero divisor occurs in its implementation. Practically, however, the phenomenon of breakdown is rarely observed. In this talk, we will try to explain this phenomenon from the probabilistic point of view and show that the probability of breakdown is actually zero.

Highly Accurate Numerical Solution Methods for Fredholm Integral Equation of the Second Kind with Semi-smooth Kernel

Fu-rong Lin
Department of Mathematics, Shantou University

Abstract
This talk is concerned with numerical solution methods for Fredholm integral equations of the second kind with semi-smooth kernel functions. We improve the continuation methods proposed in [Nystrom-Clenshaw-Curtis quadrature for integral equations with discontinous kernels, Mathematics of Computation, 72 (2002), pp. 729--756].

Applications to Wiener-Hopf equations and a Integro-differential equation are considered.

On Construction of Probabilistic Boolean Networks

Wai-ki Ching
Department of Mathematics, University of Hong Kong

Abstract:
Modeling genetic networks is an important problem in genomic research. Boolean Network (BN) and its extension Probabilistic Boolean networks (PBN) have been proposed to model genetic regulatory interactions. In a PBN, its steady-state distribution gives very important information about the long-run behavior of the network. However, one is also interested in system synthesis which requires the construction of networks. The inverse problem is ill-posed and challenging, as there may be many networks or no network having the given properties and the size of the problem is huge. The construction of PBNs from a given transition probability matrix and a given set of BNs is an inverse problem of huge size. We propose a maximum entropy approach for the above problem. Newton's method in conjunction with conjugate gradient method is then applied to solving the inverse problem. We investigate the convergence rate of the proposed method. Numerical examples are also given to demonstrate the effectiveness of our proposed algorithm.

Some Optimization Approaches for Robust and Minimization Norm Partial Quadratic Eigenvalue Assignment in Vibrating Systems

Zheng-jian Bai
Department of Information & Computational Mathematics, Xiamen University

Abstract
The partial quadratic eigenvalue assignment problem (PQEVAP) concerns reassigning a few undesired eigenvalues of a quadratic matrix pencil to suitably chosen locations and keeping the other large number of eigenvalues and eigenvectors unchanged (no spill-over). The problem naturally arises in controlling dangerous vibrations in structures by means of active feedback control design. For practical viability, the design must be robust, which requires that the norms of the feedback matrices and the condition number of the closed-loop eigenvectors are as small as possible. The problem of computing feedback matrices that satisfy the above two practical requirements is known as the Robust Partial Quadratic Eigenvalue Assignment Problem (RPQEVAP). In this paper, we formulate the RPQEVAP as an unconstrained minimization problem with the cost function involving the condition number of the closed-loop eigenvector matrix and two feedback norms. Since only a small number of eigenvalues of the open-loop quadratic pencil are computable using the state-of-the-art matrix computational techniques and/or measurable in a vibration laboratory, it is imperative that the problem is solved using

these small number of eigenvalues and the corresponding eigenvectors. To this end, a class of the feedback matrices are obtained in parametric form, parameterized by a single parametric matrix, and the cost function and the required gradient formulas for the optimization problem are developed in terms of the small number of eigenvalues that are reassigned and their corresponding eigenvectors. The problem is solved directly in quadratic setting without transforming it to a standard first-order control problem and most importantly, the significant "no spill-over property" of the closed-loop eigenvalues and eigenvectors is established by means of a mathematical result. These features make the proposed method practically applicable even for very large structures. Results on numerical experiments show that the proposed method considerably reduces both feedback norms and the sensitivity of the closed-loop eigenvalues. A study on robustness of the system responses of the method under small perturbations show that the responses of the perturbed closed-loop system are compatible with perturbations. This is a joint work with Biswa Nath Datta (NIU) and Jinwei Wang (XMU).

Document Restoration Using Inpainting and Shape-from-Shading

Andy M. Yip
Department of Mathematics, National University of Singapore

Abstract

We present a restoration framework to reduce undesirable distortions in imaged documents. Our framework is based on two components: 1) an image inpainting procedure that can separate non-uniform illumination (and other) artifacts from the printed content; and 2) a Shape-from-Shading (SfS) formulation that can reconstruct the 3D shape of the document's surface. Used either piecewise or in its entirety, this framework can correct a variety of distortions including shading, shadow, ink-bleed, show-through, perspective and geometric distortions, for both camera-imaged and flatbed-imaged documents. Our overall framework is described in detail. In addition, our SfS formulation can be easily modified to target various illumination conditions to suit different real-world applications. Results on images of synthetic and real documents demonstrate the effectiveness of our approach. OCR results are also used to gauge the performance of our approach.

A Fast Splitting Algorithm for Multi-frame Total Variation Blind Video Deconvolution

You-wei Wen
Department of Mathematics, National University of Singapore

Abstract

We consider the recovery of degraded videos without complete knowledge about the degradation. A spatially shift-invariant but temporally shift-varying video formation model is used. This leads to a simple multi-frame degradation model which relates each original video frame with multiple observed frames and point spread functions (PSF's).

We propose a variational method which simultaneously reconstructs each video frame and the associated PSF's from the corresponding observed frames. Such a multi-frame method gives much better reconstructions than single-frame methods due to the reduced ill-posedness of the multi-frame blind deconvolution problem. Total variation (TV) regularization is used on both the video frames and the PSF's to further reduce the ill-posedness and to better preserved edges. In order to make TV minimization practical for video sequences, we propose an efficient splitting method which generalizes some recent fast single-image TV minimization methods to the multi-frame case. Both synthetic and real videos are used to show the performance of the proposed method.

Quadratic Finite Element with Preconditioning for Options Pricing in Stochastic Volatility Jump-Diffusion Models

Hong-kui Pang
Department of Mathematics, University of Macau

Abstract

We exploit a quadratic finite element (FE) method for Stochastic Volatility with correlated and Contemporaneous Jumps in return and variance (SVCJ) model in option pricing. The option value function for European and barrier options satisfies a partial integro-differential equation (PIDE). After a spatial discretization of a variational formulation of the PIDE by the quadratic FE method, one arrives at an ordinary differential equation (ODE) system (which is usually referred to a semi-discretization of the variational problem). Here we integrate this ODE system in time by the extrapolation scheme based on an IMEX Euler scheme which is proposed by Feng and Linetsky [Operations Research, Vol. 56 (2008), pp. 304{325]. The coefficient matrix of the resulting linear system is block penta-diagonal with penta-diagonal blocks. Also, the coefficient matrix has certain block structure such as Toeplitz. We use the bi-conjugate gradient stabilized method to solve the linear system. To speed up the numerical process, a schur complement preconditioner is utilized. The combination of quadratic FE method, preconditioning techniques, and extrapolation scheme would be very attractive to financial engineering modelers.

A New Total Variation Method for Multiplicative Noise Removal

Yu-mei Huang
School of Mathematics and Statistics, Lanzhou University

Abstract

Multiplicative noise removal problems have attracted much attention in recent years. Unlike additive noise removal problems, the noise is multiplied to the orginal image, so almost all information of the original image may disappear in the observed image. The main aim of this talk is to propose and study a strictly convex objective function for

multiplicative noise removal problems. We also incorporate the modified total variation regularization in the objective function to recover image edges. We develop an alternating minimization algorithm to find the minimizer of such an objective function efficiently and also show the convergence of the minimizing method. Our experimental results show that the quality of images denoised by the proposed method is quite good.

Optimal Control Policy for Probabilistic Boolean Networks with Hard Constraints

Shu-qin Zhang
School of Mathematical Sciences, Fudan University

Abstract

It is well known that the control/intervention of some genes in a genetic regulatory network is useful for avoiding undesirable states associated with some diseases like cancer. For this purpose, both optimal finite-horizon control and infinite-horizon control policies have been proposed. Boolean networks (BNs) and its extension probabilistic Boolean networks (PBNs) as useful and effective tools for modelling gene regulatory systems have received much attention in the biophysics community. The control problem for these models has been studied widely. The optimal control problem in a PBN can be formulated as a probabilistic dynamic programming problem. In the previous studies, the optimal control problems did not take into account the hard constraints, i.e. to include an upper bound for the number of controls that can be applied to the captured PBN. This is important as more treatments may bring more side effects and the patients may not bear too many treatments. A formulation for the optimal finite-horizon control problem with hard constraints introduced by the authors. This model is state independent and the objective function is only dependent on the distance between the desirable states and the terminal states. An approximation method is also given to reduce the computational cost in solving the problem. Experimental results are given to demonstrate the efficiency of our proposed formulations and methods.

A Novel Framework with Compressed Sensing for Stable Gene Selection in Cancer Prediction

Li-ping Jing
Department of Computer Science, Beijing Jiaotong University

Abstract

Microarray data profiles gene expression on a whole genome scale, therefore, it provides a good way to study associations between gene expression and occurrence or progression of cancer. More and more researchers realized that microarray data is helpful to predict cancer. However, the high dimension of gene expressions which is

much larger than the sample size makes this task very difficult. Therefore, how to identify the significant genes causing cancer becomes emergency, which is also a hot and hard research topic. Many feature selection algorithms have been proposed in the past focusing on improving cancer predictive accuracy at the expense of ignoring the correlations between the features. In this work, we present a novel framework for stable gene selection which first performs compressed sensing theory to identify the important genes with high classification accuracy, and then finds their corresponding correlated genes with the correlation metrics. Real world data shows that the proposed approach often outperforms the Lasso, SAM and IG (these are the typical gene selection methods for cancer prediction).

Another Proof for Commutators with Maximal Frobenius Norm

Kin-sio Fong
Department of Mathematics, University of Macau

Abstract

It has been proved that for any $n \times n$ complex matrices *X* and *Y*,

$$\|XY - YX\|_F \leq \sqrt{2}\|X\|_F \|Y\|_F , \qquad (1)$$

where $\|\bullet\|_F$ denotes the Frobenius norm. A characterization of those pairs of matrices that satisfy (1) with equalityhas also been found. Recently, K. Audenaert has given a new proof of the inequality by introducing a matrix version of the variance. In this paper, base on his proof, we give another proof of the equality of (1). This is a joint work with C. Cheng and I. Lok.

Fast Nonconvex Nonsmooth Minimization Method for Image Restoration and Reconstruction

Chi-pan Tam
Department of Mathematics, Hong Kong Baptist University

Abstract

Nonconvex nonsmooth regularization has advantages over convex regularization for restoring images with neat edges. However, its practical interest used to be limited by the difficulty of the computational stage which requires a nonconvex nonsmooth minimization. In this talk, we present a fast minimization algorithm to solve the nonconvex nonsmooth minimization problem for image restoration and reconstruction. Our experimental results show that the effectiveness and efficiency of the proposed method.

On Selection of Regularization Parameter in Total Variation Image Restoration

Hai-yong Liao
Department of Mathematics, Hong Kong Baptist University

Abstract

Total variation (TV) based image restoration has been intensively studied recent years for its nice property of edge preservation. In this talk, I will talk about the regularization parameter problem, and present an alternative minimization method with automatic selection of regularization parameter for TV based image restoration problem. Under the framework of alternative minimization method, we solve each sub-problem and update the regularization parameter iteratively. Experimental results show that the performance of the proposed method is quite promising.

Shift-Invert Arnoldi Approximation to the Toeplitz Matrix Exponential

Spike T. Lee
Department of Mathematics, University of Macau

Abstract

The shift-invert Arnoldi method is employed to generate an orthonormal basis from the Krylov subspace corresponding to a real Toeplitz matrix and an initial vector. The vectors and recurrence coefficients produced by this method are exploited to approximate the Toeplitz matrix exponential. Toeplitz matrix inversion formula and rapid Toeplitz matrix-vector multiplications are utilized to lower the computational costs. For convergence analysis, a sufficient condition is established to guarantee that the error bound is independent of the norm of the matrix. Numerical results are given to demonstrate the efficiency of the method. This is a joint work with H. Pang and H. Sun.