Second SIAM® Conference on

LINEAR ALGEBRA

SIGNALS • SYSTEMS • CONTROL

November 5 - 8, 1990

Cathedral Hill Hotel

San Francisco, CA

Short Course on

Large-Scale and Parallel Matrix Computations in Control, Systems and Signal Processing

November 4, 1990

Preliminary Program

Conference Themes

- Signal Processing
- Large-Scale Systems
- Algebraic and Geometric Methods in Control
- Robust Control
- Numerical Issues in Control
- Large-Scale and Parallel Computations in Control
- Mathematical Systems Theory
- Identification and Estimation
- Power Systems

Sponsored by the SIAM Activity Group on Linear Algebra and co-sponsored by the SIAM Activity Group on Control and Systems Theory

Society for Industrial and Applied Mathematics

Contents

Deadline Dates

Hotel Reservations
October 15, 1990

Advance Conference Registration
October 29, 1990

Organizing Committee

David H. Carlson, Co-chair
San Diego State University

Biswa N. Datta, Co-chair
Northern Illinois University

George Cybenko
University of Illinois,
Urbana-Champaign

Robert J. Plemmons
Wake Forest University

Eduardo D. Sontag
Rutgers University

Preprints Table

For this conference, SIAM has reserved a table in the book exhibit area for those attendees who wish to share new results or ideas with other participants at the meeting. We encourage you to bring copies of your work to the meeting and make them available to those who may be interested. Also, we urge authors to submit their papers to any SIAM journals. *No advertisements or promotions, please.*

Program Overview

Following are subject classifications of titles of invited presentations (plenary and concurrent), minisymposia and contributed presentations. Codes in parentheses designate session numbers for invited presentations, plenary (IP) and concurrent (IC), minisymposia (MS) and contributed presentations (CP).

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Max-Scaling of Matrices and Weighted Graphs (IP4)
Stability and D-Stability (IC6)
Matrix Completion Problems (IC2)
Bezoutians and Matrix Equations (MS20)
Matrix Equations and Applications to Control (MS22)
Matrix Theory 1 (CP1)
Matrix Theory 2 (CP9)

Numerical Linear Algebra and Parallel Matrix Equations
Least Squares and Restricted Least Squares: Problems, Methods, and Applications (IP3)
High Accuracy Algorithms in LAPACK (IC5)
Generalizations of the Ordinary Singular Value Decomposition: Structure, Properties and Applications (IC7)
Large-Scale and Parallel Matrix Computations (MS30 and MS41)
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Asynchronous Iterative Methods: Theory and Practice (MS33)
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Signal Processing
Linear Algebra in Sensory Array Signal Processing (IP8)
Least Squares and Restricted Least Squares: Problems, Methods, and Applications (IP3)
Generalizations of the Ordinary Singular Value Decomposition: Structure, Properties and Applications (IC7)
Comparison of Adaptive Condition Estimators in Control and Signal Processing (IC3)
Mathematical Methods in Signal Processing (MS2)
Fast Algorithms for Toeplitz Matrices (MS14 and MS17)
Numerical Methods in Signals, Systems and Control (MS18 and MS25)
The Total Least Squares Problem: Analysis, Applications and Generalizations (MS23)
Performance Analysis for SVD-Based Signal Processing (MS32)
Numerical Methods in Signal Processing (CP3)

Numerical Aspects of Control and Systems Theory
Hessenberg and Block Hessenberg Forms in Linear Systems Theory (IC10)
Numerical Methods in Signals, Systems and Control (MS18 and MS25)
Numerical Eigen-Assignment (MS6)
Parallel Computations in Linear and Optimal Control (MS11)
Numerical Aspects of Optimal Control (MS29)
Numerical Methods in Control (CP10)

Large-Scale Systems
Decentralized Control and Computation (IP7)
Large-Scale Systems (MS21)

Optimization and Optimal Control
Linear Controller Design Via Nondifferentiable Convex Optimization (IC9)
Steepest Descent Problems and the Toda Lattice (IC11)
Numerical Aspects of Optimal Control (MS29)
Parallel Methods in Optimal Control (MS11)
Periodic and Optimal Control (CP5)

Robust Control
Recent Developments in Robust and H^∞ Control Theory (IP6)
Robust Stability of Interval Dynamics Systems (IC1)
Robust H_∞ and Decentralized Control (CP2)

Operator Theory
Computational Circuits for Upper Operators (IP5)
Shorted Operators (MS38)

Singular Systems
Singular Systems and Control (MS3)
Singular Systems (MS9)
Structured Matrix Problems in Signals, Systems and Control (MS34)

Polynomial Systems Theory
Matrix Polynomials and Rational Functions (MS5 and MS10)
Interpolation and Extension Problems (MS39)

Control of Power Systems
Stability and Control of Small-Signals Behavior in Power Systems (IC8)

Linear Algebra in Wavelets
Linear Algebra in Wavelet Algorithms (IC12)

(Program Overview continued)

Periodic Systems and Control
Periodic Systems and Control (MS1)
Periodic and Optimal Control (CP5)

Stochastic and Nonlinear Control
Stochastic and Structured Systems (MS12)
Stochastic Models and Control (MS35)
Algebraic Approach to Nonlinear Control (MS40)
Nonlinear Control (CP7)

Algebraic and Geometric Aspects of Linear Systems and Control Theory
Geometric and Lie Theoretic Methods for Inverse Eigenvalue Problems Arising in Control (IP1)
On Hankel Operators, Bezoutians and Algebraic Stability Criteria (IP2)
Robust Stability of Interval Dynamic Systems (IC1)
Algebraic Foundations for the Theory of Singular Linear Systems (IC4)
Observability and Linear Systems (MS4)
Systems and Behavior (MS7)
Problems in Linear Systems (MS13)
Inverse Eigenvalue Problems and Linear Systems (MS15)
Algebraic and Geometric Methods in Linear Systems Theory (MS19)
Geometric Aspects of the Matrix Riccati Equation (MS24)
Parameter Identification and Observability (MS27)
Advanced Geometric Techniques (MS28)
Linear Control Systems (CP8)

SHORT COURSE

Large-Scale and Parallel Matrix Computations in Control, Systems and Signal Processing

November 4, 1990
Cathedral Hill Hotel
San Francisco, CA

Organizer:
Biswa N. Datta, Department of Mathematical Sciences, Northern Illinois University

Practical situations such as the design of large space structures and the control of power systems give rise to very large scale problems in control. However, research in large-scale and parallel computations in control is still in its infancy. Control theory is lagging behind other areas of applied sciences and engineering. This concern has been raised in the recent panel report on "Future Directions in Control Theory", where, among other findings, computations has been clearly pointed out.

Linear and numerical linear algebra tools have been used very often effectively in the past to solve small and dense matrix computations and the matrix contol problems. However, the techniques of large scale and sparse matrix computations and the matrix algorithms that are capable of exploiting the powerful multiprocessing nature of the existing and future generation parallel and vector computers, have not been fully utilized in control theory.

The purpose of this short course is to give the participants an overview of current large-scale and parallel algorithms in numerical linear algebra and show how these algortihms can be profitably used in control problems. State-of-the-Art techniques will be emphasized.

The course is divided into two parts. Part I will deal with techniques of large-scale and parallel matrix computations, and Part II will be devoted to applications of these techniques to control, systems and signal processing problems.

The course is designed for mathematicians, computer scientists and control, systems, and signal processing engineers. A basic knowledge of numerical linear algebra and control theory is a prerequisite.

Program	
A.M.	
8:15 - 9:00	**Overview and Introduction**
9:00 - 10:00	**Parallel algorithms for dense matrix computations.** Ahmed Sameh, Center for Supercomputing Research and Development, University of Illinois, Urbana-Champaign
10:00 - 10:30	Coffee
10:30 - 11:30	**Parallel algorithms for sparse matrices.** Iain Duff, Rutherford Appleton Laboratory and CERFACS
11:30 - 12:30	**An overview of Krylov subspace methods and applications to control.** Youcef Saad, Research Institute for Advance Computer Science (RIACS)
P.M.	
12:30 - 2:00	Lunch
2:00 - 3:30	**Large scale and parallel computations in control.** Biswa N. Datta, Northern Illinois University
3:30 - 4:00	Coffee
4:00 - 5:00	**Mapping of Kalman filtering onto parallel architectures.** R.S. Baheti, General Electric and National Science Foundation
5:00 - 5:30	Discussions

Registration Fees*

	SIAM Member	Non-Member	Student
Advance	$115	$135	$75
On-site	135	155	95

*Registration fee for the Short Course includes preprints, coffee and lunch. Please use the registration card found on the inside back cover of this program.

Attendees should preregister for the Short Course, as on-site registration can not be guaranteed. Preprints of the lecture materials will be distributed upon check-in at the registration desk.

INVITED PRESENTATIONS

PLENARY

Monday, November 5/8:30 AM
IP1

Geometric and Lie Theoretic Methods for Inverse Eigenvalue Problems Arising in Control

Being a prescriptive rather than a descriptive subject, systems and control theory is a rich source of inverse problems. For processes that can be reasonably modeled as finite-dimensional linear systems, many of these problems give rise to interesting but sometimes quite difficult inverse problems involving matrices. One particular source of mathematical difficulty is the practical constraint that solutions of these inverse problems must be real. Consequently, complex methods must be supplemented with a much more refined analysis.

The speaker will focus on a class of inverse eigenvalue problems that remain open despite some impressive advances involving applications of methods from algebraic geometry, combinatorics and topology. He will also highlight some remarkable recent results in these areas that have been obtained by combining these geometric approaches with Lie algebraic methods.

Christopher Byrnes
Department of Systems Science and Mathematics
Washington University

Monday, November 5/9:15 AM
IP2

On Hankel Operators, Bezoutians and Algebraic Stability Criteria

The speaker will give a survey of the general theory of the Hankel quadratic forms and its relation to other forms, particularly Bezoutians. In particular, he will outline the connection with continued fractions and give some geometric interpretations. He will review the connection with system theory problems, focussing on realization theory, the partial realization problem, balancing, orthogonal polynomials and algebraic stability criteria.

Paul A. Fuhrmann
Department of Mathematics
Ben Gurion University of the Negev, Israel

Tuesday, November 6/8:30 AM
IP3

Least Squares and Restricted Least Squares: Problems, Methods, and Applications

Linear parameter estimation problems in signal processing, system identification and control problems in general lead to least squares problems involving overdetermined linear systems AX=B. The speaker will survey recent advances in algorithms for solving least squares and, more generally, restricted least squares problems. The speaker will address questions of efficiency, reliability, and accuracy and will also comment on some features of least squares algorithms developed for LAPACK.

Ake Bjorck
Department of Mathematics
Linkoping University, Sweden

Tuesday, November 6/9:15 AM
IP4

Max-Scaling of Matrices and Weighted Graphs

In this talk we report on MAX analogues of classical SUM scaling results. A diagonal similarity of A is a matrix of form DAD^{-1}. Let A be a square nonnegative matrix. The matrix A is max-balanced if the maximum of the entries in each row is equal to the maximum of the entries in the corresponding column. We describe an algorithm which finds a diagonal matrix D such that DAD^{-1} is max-balanced, whenever this is possible. We give characterizations of max-balanced matrices. For symmetric A we give necessary and sufficient conditions for the existence of a diagonal D such that DAD has prescribed row sums, and we describe an algorithm that finds such a D. We apply these results to the diagonal equivalence scaling scaling DAE of a rectangular nonnegative matrix A to formulated as additive problems for weighted graphs.

Hans H. Schneider
Department of Mathematics
University of Wisconsin, Madison

Wednesday, November 7/8:30 AM
IP5

Computational Circuits for Upper Operators

An "upper" operator is a generalization of an upper triangular matrix to infinite dimensions. It corresponds to the transfer representation of a causal, time-varying system. Recent research has shown that much of classical filter theory goes through in the setting of this general class of operators.

The speaker will present a theory of 'finite dimensional' computational circuits in the taste of classical rational transfer function theory, describe how to approximate infinite operators by finite ones using an extended Schur algorithm and how to solve a Nevanlinna-Pick type interpolation, and describe applications to estimation theory, model reduction theory and control. The theory makes extensive use of a new transform technique called the "W-transform", which plays a role akin to the classical z-transform.

Patrik Dewilde
Delft University of Technology
The Netherlands

Wednesday, November 7/9:15 AM
IP6

Recent Developments in Robust and H^∞ Control Theory

Robust control problems arise whenever modeling uncertainty is a significant issue in control design. Modeling uncertainty is caused by inaccurate and incomplete data, simplifying assumptions in the modeling process, linearization of nonlinear systems, etc. H^∞ optimal control theory is a major new tool in the synthesis of robust control systems.

The speaker will present an overview of some of the recent developments in robust and H^∞ multivariable control theory, and will describe a state-space solution to the H^∞ optimal control and filtering problems. He will also consider some multiple objective optimal control problems, and discuss possible advantages of nonlinear time-varying vs. linear time-invariant controllers in robust control of linear time-invariant plants.

Pramod P. Khargonekar
Department of Electrical Engineering and
Computer Science
University of Michigan, Ann Arbor

Thursday, November 8/8:30 AM
IP7

Decentralized Control and Computation

Decentralized control is a challenging concept in system theory. Driven by the modern trend toward distributed parallel processing in computer architecture, the theory of decentralized control is in a chaotic but exciting new phase of development. A large number of mathematical concepts have been proposed for control of complex dynamic systems consisting of many subsystems, which have access to different information and are controlled by their own local control laws, but must work in a coherent fashion to achieve a stable and robust, if not optimal, overall performance.

The speaker will critically review the present activities and prospects of research in decentralized control of complex systems with an emphasis on dimensionality, information structure constraints, and uncertainty. Special attention is devoted to decompositions of large systems, which are conducive to decentralized control strategies. In this context, the Inclusion Principle for dynamic systems will be presented, which offers new insights and computational possibilities for solving control problems with overlapping information sets. A mixture of graph-theoretic concepts, geometric notions, and matrix analysis is used to provide an environment for new and interesting research in a joint venture of decentralized control schemes and distributed computing architectures.

Dragoslav D. Siljak
Department of Electrical Engineering and
Computer Science
Santa Clara University

Thursday, November 8/9:15 AM
IP8

Linear Algebra in Sensor Array Signal Processing

Sensor array signal processing deals with the problem of extracting information from signals received at an array of spatially distributed sensors. The information desired could be quite varied such as signal shapes, powers and directions of arrival. In the last decade, several new solution methods have been introduced that have a high-resolution property, viz., they give the exact answers as the signal-to-noise ratio or the number of observations tends to infinity. Several linear algebraic concepts and tools are exploited in these new algorithms, e.g., subspace and generalized eigenvalue decompositions, least-squares and total least-squares criteria, and Schur (or Hadamard) matrix products. The speaker will present a survey of such results with emphasis on the so-called MuSIC and WSF (weighted subspace fitting) subscapes and ESPRIT algorithms.

Thomas Kailath
Department of Electrical Engineering
Stanford University

Invited Presentations

CONCURRENT

Monday, November 5/2:00 PM
IC1

Robust Stability of Interval Dynamic Systems

The area of robust stability under parametric perturbations received new impetus with the advent of Kharitonov's theorem, and significant engineering design and analysis problems that were previously intractable can now be solved. In this talk the speaker will discuss Kharitonov's theorem, its subsequent generalizations and its impact on the area of robust control. The extremality properties of these results and their efficiency will be explored. Open problems in robust control will be proposed for research.

S. P. Bhattacharyya
Department of Electrical Engineering
Texas A&M University

Monday, November 5/2:00 PM
IC2

Matrix Completion Problems

The speaker will survey this rapidly growing area in which conditions are studied for a partially known matrix so that it can be completed to a matrix with desired properties. Some well-developed portions of the subject will be described in detail (e.g. the positive definite case or certain spectral results), while others in which a great deal of development is needed will be mentioned more briefly. Time permitting, the speaker will discuss the current state of the controllable matrix-vector pair problem.

Charles R. Johnson
Department of Mathematics
College of William and Mary

Monday, November 5/2:00 PM
IC3

Comparison of Adaptive Condition Estimators in Control and Signal Processing

Estimates for the condition number of a matrix are required in many areas of scientific computing, including: recursive least squares computations, optimization, and general nonlinear problems solved by linearization techniques where matrix modifications are used.

The speaker will present a comparison of several condition estimators in the context of updating and downdating the Cholesky factor over time. The incremental condition estimator, ice, due to Bischof, the adaptive condition estimator, ace, due to Pierce and Plemmons, and the adaptive Lanczos condition estimator, ale, by Ferng, Golub and Plemmons will be included. Comparisons are made on recursive least squares problems arising in control and signal processing.

Robert J. Plemmons
Department of Mathematics and Computer Science
Wake Forest University

Tuesday, November 6/2:00 PM
IC4

Algebraic Foundations for the Theory of Singular Linear Systems

The dynamics of a classical linear system is given by a polynomial module structure on the state space. Singular linear systems have poles at infinity, and the dynamical structure there is given by a module action over the local ring at infinity. Spaces of multivariable zeros (both finite and at infinity) admit analogous module actions.

Global spaces of poles and zeros are given as the direct sum of modules over different rings. What algebraic structure captures the dynamics of such spaces? The speaker will describe global filtrations which unify the m-adic filtrations and Wedderburn's idea of the degree of a rational vector.

Bostwick F. Wyman
Department of Mathematics
Ohio State University, Columbus

Tuesday, November 6/2:00 PM
IC5

High Accuracy Algorithms in LAPACK

The speaker will describe new high accuracy algorithms in LAPACK, a portable linear algebra library for supercomputers. Backward stability, in which the computed answer for problem A is exact for the perturbed problem A+E, is used. In conventional algorithms, E is only small in norm. This respects neither the sparsity nor scaling of A. In contrast, in these high accuracy algorithms each entry of E is small compared to the corresponding entry of A. This leads to significantly more accurate answers for linear equations, least squares, the bidiagonal SVD, the tridiagonal symmetric eigenproblem, the dense symmetric positive definite eigenproblem, the dense SVD, and some indefinite and generalized eigenproblems.

James Demmel
Departments of Mathematics and Computer Science
University of California, Berkeley

Tuesday, November 6/2:00 PM
IC6

Stability and D-Stability

The classical criteria for matrix stability such as Lyapunov Theorem, the Routh-Hurwitz criterion, and use of Bezoutiants lead to classes of stable matrices such as the positive definite Hermitian matrices, the totally nonnegative matrices and the M-matrices. These examples suggest two conjectures on sufficient conditions for stability due to Carlson and to Varga. Many concepts related to stability have been found useful in a variety of contexts. Several of these concepts involve using nonsingular diagonal matrices to perturb a given matrix in various ways. These include D-stability, Additive D-stability and Lyapunov diagonal stability. These also include multiplying a given matrix by a (often positive) diagonal matrix to produce a stable matrix. Normally, characterization of the various types of matrix stability is a hard open problem. Recently, it has been solved in the acyclic case and the H-matrix case. Inertia preserving matrices strongly related in concept to D-stability and Lyapunov diagonal stability, have recently been introduced and investigated. The speaker will survey classical and modern concepts in matrix stability.

Daniel Hershkowitz
Department of Mathematics
Technion - Israel Institute of Technology, Israel

Wednesday, November 7/2:00 PM
IC7

Generalizations of the Ordinary Singular Value Decomposition: Structure, Properties and Applications

The ordinary singular value decomposition (OSVD) has become an important tool in the analysis and numerical solution of mathematical problems. Recently, a collection of generalizations for the OSVD was discovered. It contains the Product (PSVD) and Quotient (QSVD) singular value decomposition for two matrices as its basic elements. The structure and geometrical properties of these two basic decompositions led to similar factorizations for 3,4, etc... matrices. The speaker will discuss in detail the structure of this tree of generalizations and treat the geometrical properties as well as several applications.

Bart L.R. De Moor
ESAT - Department of Electrical Engineering
Katholieke Universiteit Leuven, Belgium

Wednesday, November 7/2:00 PM
IC8

Stability and Control of Small-Signal Behavior in Power Systems

Large power systems can display slow (0.1-2 Hz) and poorly damped or unstable oscillations of frequency, power or voltage around their nominal values. The speaker will outline approaches in the power systems community to analyzing and controlling these oscillations. The central task is computation of selected modes, and their sensitivities to control parameters, in models comprising hundreds of state variables and constraint equations. Physical insight and tools for exposing underlying structure are important in developing efficient algorithms. The speaker will describe recent results obtained by 'Selective Modal Analysis' approach, which is under continuing development in joint work with Ignacio Perez-Arriaga and coworkers.

George C. Verghese
Laboratory for Electromagnetic and Electronic Systems
Massachusetts Institute of Technology

Wednesday, November 7/2:00 PM
IC9

Linear Controller Design Via Nondifferentiable Convex Optimization

The speaker will describe an approach to the analysis and design of linear control systems that is based on numerical convex optimization over closed-loop transfer functions. Convexity makes numerical solution effective: it is possible to determine whether or not there is a controller that achieves a given set of specifications. Thus, the limit of achievable performance can be computed. Although the basic idea behind this approach can be traced back into the 1950's, two developments since then have made it more attractive and useful. The first is a simple description of the achievable closed-loop behaviors for systems with multiple sensors and actuators. The second is the development of powerful numerical algorithms for solving convex optimization problems, and powerful computers to run them. The speaker will describe an implementation of a controller design code, QDES which is based on this approach.

Stephen Boyd **and Craig Barratt**
Department of Electrical Engineering

Parallel Computations in Optimal Control

Parallelism has introduced challenging new problems in scientific computing. A fundamental challenging question is the design of new algorithms or new implementations of existing algorithms that can be easily parallelized. Though much work has been done in numerical linear algebra and several application-areas such as numerical solutions of partial differential equations, fluid dynamics, etc., parallel algorithms for control problems are virtually nonexistent. On the other hand, there are practical situations such as the design of large space structures, control of power systems, etc. that give rise to control problems that are so large that they can be termed "supercomputer problems". The need for more active research in the area has been clearly mentioned in a recent panel report "Future Directions in Control Theory: A Mathematical Prospective," SIAM, 1989.

This minisymposium is one of two that have been organized. The other is on Parallel Computations in Linear Control. The speakers in these sessions will describe "state-of-the-art" techniques of the limited activities in these areas and address the needs of more active research with some practical open problems.

Invited Presentations

CONCURRENT

Thursday, November 8/2:15 PM
IC11
Steepest Descent Problems and the Toda Lattice

In this presentation, based on joint work with R. Brockett, H. Flaschka and T. Ratiu, the speaker will discuss a class of matrix equations which are related to the integrable Toda lattice equations. These equations, originally exhibited by R. Brockett as steepest descent equations on a flag manifold, possess many elegant mathematical properties. They have a number of interesting invariant subspaces and the flow may be mapped (via the so-called "momentum mapping") to a convex polytope with the equilibria of the flow at the vertices of the polytope. Moreover, this class of equations gives the solution to symmetric eigenvalue problems, the Total Least Squares problem, and certain linear programming and sorting problems.

Anthony M. Bloch
Department of Mathematics
Ohio State University, Columbus

Thursday, November 8/2:15 PM
IC12
Linear Algebra in Wavelet Algorithms

Wavelets are functions that determine decompositions of functions and signals and as such define an interesting class of transformations. The speaker will describe the linear algebra underlying wavelet theory and algorithms in this presentation. He will give special attention to relationships to filtering and decimation/interpolation by general factors, and will present some results on multidimensional indecomposable wavelets.

George Cybenko
Center for Supercomputing Research and Development
University of Illinois, Urbana

Get-Togethers

Minisymposia

Monday, November 5/10:30 AM
MS1
Periodic Systems and Control

The considerable development of the theory of Periodic Systems and Control in the last decade has a twofold motivation: Firstly the necessity of working out suitable tools for the control of intrinsically periodic systems and secondly the opportunity of robustifying control schemes of time-invariant plants by means of periodic controllers. This minisymposium will consist of four lectures devoted to advanced topics in the field. Special emphasis will be given to recent advances in robust control and state estimation, with a view on the applications to space problems.

Organizer: Sergio Bittanti
Politecnico di Milano, Italy

Periodic Systems and Robust Control
Pramod P. Khargonekar, The University of Michigan, Ann Arbor

State Estimation for Linear Periodic Systems With and H_∞ Performance Criterion
Lihua Xie and *Carlos E. de Souza*, University of Newcastle, Australia

Estimation and Control in Continuous Periodic Systems and Their Application to Space Problems
T. Nishimura, The Institute of Space and Astronomical Science, Japan

Recent Advances in Optimal Filtering and Control of Periodic Systems
To be presented by organizer

Monday, November 5/10:30 AM
MS2
Mathematical Methods in Signal Processing

The mathematical theory of signal processing is a rich and varied field. Some of the mathematical techniques and related computational techniques that arise in signal processing will be addressed.

Organizer: James R. Bunch
University of California, San Diego

Unitary Problems in Signal Processing
Jeffrey M. Speiser, Naval Ocean Systems Center, San Diego

High Resolution Image Reconstruction
Harper Whitehouse, Naval Ocean Systems Center, San Diego

Eigenvalues and Wavelet Transforms
Christopher E. Heil, The MITRE Corporation, McLean, VA

Computational Problems Arising in Direction of Arrival Algorithms
To be presented by organizer

Monday, November 5/10:30 AM
MS3
Singular Systems and Control

Many problems in control theory, and engineering in general, are most naturally initially formulated as an implicit system of differential equations $F(y',y,t) = 0$. In the last decade there has been an increasing interest in working with the equations in their original implicit formulation. Reasons for doing so have ranged from greater flexibility in modeling and simulation to numerical advantages. This minisymposium will consider singular implicit equations, also known as descriptor or differential-algebraic (DAE), where F is singular along trajectories. The talks will emphasize either new directions that the linear time invariant theory is currently taking or recent advances in the linear time varying (and nonlinear) theories.

Organizer: Stephen L. Campbell
North Carolina State University

Structural Primitives in Singular Control and Their Numerical Solution
Kenneth D. Clark, U.S. Army Research Office

Differential Inclusions and Implicit Control Systems
Helene Frankowska, CNRS, Ceremade, Universite de Paris-Dauphine, France

Duality of Observability and Controllability for Time Varying Descriptor Systems
Stephen L. Campbell, North Carolina State University; *Nancy K. Nichols*, University of Reading, United Kingdom

Control of Discrete-time Descriptor Systems
Bernard C. Levy, University of California, Davis; Alan S. Willsky, Massachusetts Institute of Technology; and *Ramine Nikoukhah*, INRIA, Rocquencourt BP105, France

Monday, November 5/10:30 AM
MS4
Observability and Linear Systems

Observability is the process of distinguishing between orbits of a dynamical system on the basis of incomplete measurements. This problem is often taken for granted in control theory, but it has been noted in the last decade that the problem of observability makes contact with a very large number of areas in mathematics. The object of this minisymposium is to consider four very different aspects of this problem and to examine the mathematics of observability. All four of the talks presented here have aspects that place them in the context of linear algebra even though the problems are for the most part nonlinear.

Organizer: Clyde Martin
Texas Tech University

Decentralized Systems and Projective Product Varieties
Xiaochang Wang, Texas Tech University

Observability and Invariant Differential Operators
Dorothy Andreoli, Dartmouth College; *Joseph A. Wolf*, University of California, Berkeley

Universal Observability and Chaos
Alisa A. DeStefano, Dartmouth College

Discrete Observability of Nonlinear Systems Using Continuation Techniques
Clyde Martin and *John Miller*, Texas Tech University

Monday, November 5/10:30 AM
MS5
Matrix Polynomials and Rational Functions (Part 1 of 2)

The purpose of this minisymposium is to report on a variety of important recent advances in matrix polynomials and rational matrix functions, with strong emphasis on developments that stem from, or are leading to, applications in systems, control and signal processing. Many such developments for rational matrices, (interpolation, minimal factorization, and others) are based on state space methods, and have applications in such areas as H^∞- control, linear quadratic control, cascade systems, numerical algorithms for control problems, etc. On the other hand, orthogonal matrix polynomials and Bezoutians are closely connected to inversion of block Toeplitz matrices and problems in signal processing. Recent results on other important topics in the general area of

matrix polynomials and rational matrix functions (such as variational principles for matrix polynomials) will be represented as well.

Organizer: Leiba Rodman
College of William and Mary

Orthogonal Matrix Polynomials
L. Lerer, Technion - Israel Institute of Technology, Israel

Variational Principles for Linear and Quadratic Matrix Polynomials
Qiang Ye, University of Calgary, Canada

Minimal and Maximal Polynomial Paths and the Invariant Factors of a Matrix Product
Ion Zaballa, Universidad del Pais Vasco, Spain

Tangential Lagrange-Sylvester Interpolation with Infinite Order Constraints
Joseph A. Ball and *Marek Rakowski*, Virginia Tech

Interpolation Problems for Rational Matrix Functions with Incomplete Data
I. Gohberg, Tel-Aviv University, Israel; M.A. Kaashoek and *A.C.M. Ran*, Vrije Universiteit, The Netherlands

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Monday, November 5/10:30 AM
MS6

Numerical Eigen-assignment

Eigenvalue and eigenvector assignment problems are the kernels of many important problems in control theory.

These problems have been well-studied in control theory literature, both from theoretical and computational view points. However, there are aspects of these problems, which still need careful attention and an active research is being pursued. The current research mostly focuses on the development of output feedback algorithms determined conditioning of the problems, robust eigenvalue assignment, partial eigenvalue assignment and development of parallel algorithms.

The speakers in this session will present results of their current research in some of these areas.

Organizer: Biswa N. Datta
Northern Illinois University

Sequential and Parallel Algorithms for the Multi-Input Eigenvalues Assignment Problem
Mark Arnold and Biswa N. Datta, Northern Illinois University

Approximate Pole Assignment
King-wah Eric Chu, Monash University, Australia

Approximation Methods for Eigenstructure Assignment by Output Feedback
Daniel C. W. Ho, City Polytechnic of Hong Kong, Hong Kong, and L. R. Fletcher, University of Salford, United Kingdom

An Algorithm for the Pole Assignment Problem of Descriptor Systems with Output Feedback
George Miminis, Memorial University of Newfoundland, Canada

Monday, November 5/3:15 PM
MS7

Systems and Behaviors

The 'behavior' of a system is the set of all possible trajectories of the vector of variables of interest (say, port variables). Although this notion appears more or less explicitly in classical work, it has been realized only recently (mainly through the work of Jan Willems) that the use of behaviors is crucial to the understanding of many problems in system theory -- the reason being basically that behaviors exist independently from a specific representation and can therefore, be used as a bridge between representations of different types. In this minisymposium, it will be shown how the 'behavioral strategy' can be applied to a variety of research problems.

Co-organizers: A.C. Antoulas, ETH - Zurich, Switzerland and J.M. Schumacher, Center for Mathematics and Computer Science, The Netherlands

A Survey of External Equivalence
J.M. Schumacher, Center for Mathematics and Computer Science, The Netherlands

Aggregation of Linear Systems
Giorgio Picci, University of Padova and LADSEB-CNR, Italy

The Behavior Approach to Realization Theory
A.C. Antoulas, ETH - Zurich, Switzerland

Monday, November 5/3:15 PM
MS8

Iterative Methods and Algorithms

Iterative methods and algorithms for solving large sparse systems of linear algebraic equations encompass a variety of ingrained challenges. Some of these include the selection of the method appropriate to the problem, the starting strategies to use, the preconditioning procedure involved, the implementation of the algorithm, and the various computational details related to the software. This minisymposium will highlight current research efforts for several of these specific issues.

Organizer: David R. Kincaid
University of Texas, Austin

Modified Successive Overrelaxation (MSOR) and Equivalent 2-Step Iterative Methods for Collocation Matrices
Yiannis G. Saridakis, Clarkson University; *Apostolos Hadjidimos*, Purdue University

Preconditionings for Least Squares Problems
Youcef Saad, NASA, RIACS

Non-Optimal Starting Strategies Produce Optimal Control
John de Pillis, University of California, Riverside

A Matrix Analysis of Conjugate Gradient Algorithms
Martin H. Gutknecht, Eidgenossische Technische Hochschule, Switzerland; *Steven F. Ashby*, Lawrence Livermore National Laboratory

Linear Stationary Second-Degree Methods for the Solution of Large Linear Systems
David M. Young, and *David R. Kincaid*, University of Texas, Austin

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Monday, November 5/3:15 PM
MS9

Singular Systems

Singular control systems of the form $Ex=Ax+Bu(t)$ with E singular have received a lot of interest recently. They are generalizations of standard control systems and can be used for example to combine differential and algebraic equations. Aspects of this minisymposium are theoretical linear algebra questions as well as computational methods.

Organizer: Volker Mehrmann
Institut fur Geometrie und Praktische Mathematik, West Germany

A Computational Approach to the Geometry of Singular Systems
G. Beauchamp and *F.L. Lewis*, Georgia Institute of Technology

The Geometry of Singular Systems
Uwe Helmke, University of Regensburg, West Germany

Singular Systems as Limits Under High Gain Feedback
Joyce O'Halloran, Portland State University

State Space Formulas for Transfer Poles at Infinity
Margreet Kuijper and *J.M. Schumacher*, University of Tilburg, The Netherlands

Descriptor System Structure and Generalized Optimal Control
Ton Geerts, Technische Universiteit Eindhoven, The Netherlands

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Monday, November 5/3:15 PM
MS10

Matrix Polynomials and Rational Functions (Part 2 of 2)

(for overview of session, please refer to Part 1, Minisymposium 5)

Organizer: Leiba Rodman
College of William and Mary

Matrix Polynomials with Prescribed Zero Structure in the Finite Complex Plane
M.A. Kaashoek, Vrije Universiteit, The Netherlands

Minimal Factorization of Rational Matrices: Developments, Perspectives and Open Problems
Joos Vandewalle, Shaohua Tan and *B. De Moor*, Katholieke Universiteit Leuven, Belgium

State Variable Realizations of Rational Interpolants
B.D.O. Anderson, Australian National University, Australia; *A.C. Antoulas*, ETH-Zurich, Switzerland

Simultaneous Interpolation Problems for Rational Matrix Functions
J.A. Ball, Virginia Tech; I. Gohberg, Tel-Aviv University, Israel; and *Leiba Rodman*, College of William and Mary

Bezoutians of Matrix Polynomials and Inversion of Matrices
I. Gohberg, Tel-Aviv University, Israel; *T. Shalom*, The College of William and Mary

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Monday, November 5/3:15 PM
MS11

Parallel Computations in Optimal Control

Parallelism has introduced challenging new problems in scientific computing. A fundamental challenging question is the design of new algorithms or new implementations of existing algorithms that can be easily parallelized. Though much work has been done in numerical linear algebra and several application-areas such as numerical solutions of partial differential equations, fluid dynamics, etc., parallel algorithms for control problems are virtually nonexistent. On the other hand, there are practical situations such as the design of large space structures, control of power systems, etc. that give rise to control problems that are so large that they can be termed "supercomputer problems". The need for more active research in the area has been clearly mentioned in a recent panel report "Future Directions in Control Theory: A Mathematical Prospective," SIAM, 1989.

This minisymposium is one of two that have been organized. The other is on Parallel Computations in Linear Control. The speakers in these sessions will describe "state-of-the-art" techniques of the limited activities in these areas and address the needs of more active research with some practical open problems.

MINISYMPOSIA

Organizer: Biswa N. Datta
Northern Illinois University

Title to be included in final program
J. Duncan, North Carolina State University

Parallel and Vector Methods for Stochastic Dynamic Programming
F.B. Hanson,S.-L. Chung and H.H. Xu, University of Illinois, Chicago

On the Implementation and Performance of Parallel Gradient Projection Algorithms for Optimal Control
Gerard G. L. Meyer, The Johns Hopkins University, and *Louis J. Podrazik*, Institute for Defe se Analysis

Partitioned Dynamic Programming
Stephen J. Wright, North Carolina State University

Tuesday, November 6/10:30 AM
MS12

Stochastic and Structured Systems

Linear algebra plays a crucial role in modelling, identification and realization problems for linear stochastic and structured systems. Various aspects of the stochastic system model will be discussed in the minisymposium. The first lecture is concerned with the realization problem for discrete-time second order stochastic processes - both in ARMA and MFD forms. This will be followed by models of reciprocal processes and Markov random fields. This may be looked at as non-causal ARMA type realizations. The likelihood ratio for such models in the 2-D case will be presented in the third lecture, where continuous-time questions will also be discussed. Finally, the realization problem for continuous-time second-order processes will be presented. All the models considered will be linear. There will be interesting applications of results from linear algebra in all the lectures.

Organizer: A. Bagchi
University of Twente, The Netherlands

Forward and Backward Canonical ARMA and MFD Realizations of Second Order Stochastic Processes
J. Bokor and L. Keviczky, Hungarian Academy of Sciences, Hungary

Multiscale Models and Estimation of Discrete Gauss-Markov Random Fields
Bernard C. Levy, University of California, Davis

Likelihood Ratio for 2-D Processes
A. Bagchi, University of Twente, The Netherlands, *R. Luesink*, University of Twente, The Netherlands

How to Achieve Positivity by State-Feedback
Giorgio Picci, Universita di Padova and LADSEB-CNR, Italy; Stefano Pinzoni, LADSEB-CNR, Italy

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Tuesday, November 6/10:30 AM
MS13

Problems in Linear Systems

The minisymposium addresses two general themes of current interest in the theory of linear systems. The first concerns generalized/descriptor state-space systems. Results are presented on pole assignment for the allocation of specified dynamics, including the infinite frequency structure. An alternative approach establishes a class of systems which can be transformed into the case when the coefficient matrix of the vector derivative is nonsingular. The second area involves transfer function representations. One paper extends results on transformations between realizations to multi-dimensional systems, including the concept of comprimeness. The final paper gives an algorithm for reducing a scalar transfer function to its lowest terms by applying elementary row operations to an observability matrix.

Organizer: Stephen Barnett
University of Essex, United Kingdom

Some Results in Pole Structure Assignment in Generalized State Space Systems
A.C. Pugh and E.R.L. Jones, Loughborough University of Technology, United Kingdom; G.E. Hayton, Hull University, United Kingdom

Remarks on Optimal Control and State Estimation of a Class of Linear Time-Invariant Descriptor-Variable Control Systems
V. Lovass-Nagy, R.J. Schilling and R. Mukundan, Clarkson University

Linear Transformations of Multi-Dimensional Systems
G.E. Hayton, The University of Hull, United Kingdom; A.C. Pugh, Loughborough University of Technology, United Kingdom

Reduction of a Transfer Function via an Observability Matrix
To be presented by organizer

Tuesday, November 6/10:30 AM
MS14

Fast Algorithms for Toeplitz Matrices (Part 1 of 2)

Toeplitz matrices arise in many engineering applications. Since an nxn Toeplitz matrix is defined by at most 2n-1 parameters it is often possible to (numerically) solve linear algebra problems defined by Toeplitz matrices in $O(n^2)$ flops. This minisymposium will consider new developments in these fast techniques for linear algebra problems that have Toeplitz structures.

Co-organizers: Adam W. Bojanczyk and
Franklin T. Luk
Cornell University

Algorithms for Nonsymmetric Toeplitz Linear Systems
Adam W. Bojanczyk, Cornell University

The Use of Pivoting in Linear-Time Systolic Algorithms for the Solution of Toeplitz Problems
Douglas Sweet, James Cook University, Australia

Design of Preconditioners for Symmetric Positive Definite Block Toeplitz Matrices
Takang Ku and *C.-C. Jay Kuo*, University of Southern California

A Stable Extension of Levinson's Algorithm for Indefinite Toeplitz Systems
Per Christian Hansen and *Tony F. Chan*, University of California, Los Angeles

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Tuesday, November 6/10:30 AM
MS15

Inverse Eigenvalue Problems and Linear Systems

Overview of minisymposium will appear in final program.

Organizer: Christopher I. Byrnes
Washington University

A System Theoretic Proof of the Cauchy-Weyl Separation Theorem
J. Lund, Montana State University; *Christopher I. Byrnes*, Washington University

Eigenvalue Assignment and Analogous Problems in Algebraic Codes
Clyde Martin and *Minerva Cordero-Vourtsanis*, Texas Tech University

Central Projection and Feedback Pole Placement
Xiaochang Wang, Texas Tech University

Quantifying Information Content in Parameter Identification Via Singular Values
J. Lund and *Curt Vogel*, Montana State University

Tuesday, November 6/10:30 AM
MS16

Parallel Computations in Linear Control

(For overview of session, please refer to Minisymposium 11)

Organizer: Biswa N. Datta
Northern Illinois University

Parallel Algorithms for the Eigenvalue Assignment Problem
Amit Bhaya and Biswa N. Datta, Northern Illinois University

A Multiplication-Rich Algorithm for Solving a Class of Lyapunov Equations
Judith D. Gardiner, Ohio State University

Distributed and Shared Memory Block Algorithms for the Triangular Sylvester Equation with Sep(-1) Estimators
Bo Kagstrom and Peter Poromaa, University of Umea, Sweden

A Pipelined Architecture of a Novel Mimo State-Space Identification Method
Michel Verhaegen, Alle-Jan van de Veen and Ed. F. Deprettere, Delft University of Technology, The Netherlands

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Tuesday, November 6/3:15 PM
MS17

Fast Algorithms for Toeplitz Matrices (Part 2 of 2)

(See previous description, Minisymposium 14)

Co-organizers: Adam W. Bojanczyk and
Franklin T. Luk
Cornell University

On Algorithms for Solving Structured Linear Systems
Ilse Ipsen, Yale University

A Relatively Unknown Fast Toeplitz Algorithm
Adam W. Bojanczyk, Tong J. Lee and *Franklin T. Luk*, Cornell University

On Fast Householder Filtering RLS Algorithms
John Cioffi, Stanford University

Numerical Solution of the Eigenvalue Problem for Efficiently Structured Hermitian Matrices
William F. Trench, Trinity University

Tuesday, November 6/3:15 PM
MS18

Numerical Methods in Signals, Systems and Control (Part 1 of 2)

Modern control problems put ever increasing demands on numerical methods. Robust designs control and H^∞ control lead to eigenvalue and singular value problems with special structure and constraints. Tracking time varying descriptor systems requires smoothly varying bases of invariant subspaces and singular spaces. Some traditional methods destroy sparsity, symmetry or other structures making some large scale problems intractable and allowing rounding errors to corrupt the accuracy of others. The minsymposium will focus on recent developments in numerical linear algebra that extend

the boundaries of what can be calculated and the accuracy which can be obtained.

Organizer: Ralph Byers
University of Kansas

The Schur Parameter Form for the Solution of the Unitary Eigenvalue Problem
Ludwig Elsner and *Angelika Bunse-Gerstner*, Universitat Bielefeld, West Germany

Algorithms for the Unitary Eigenproblem and Applications
Lothar Reichel, University of Kentucky

A Structure Preserving Algorithm for Solving the Algebraic Riccati Equation of Control Theory
Gregory Ammar, University of Kentucky

Numerical Computation of a Smooth Singular Value Decomposition of a Matrix Valued Function
Angelika Bunse-Gerstner, Universitat Bielefeld, West Germany; Ralph Byers, University of Kansas; Nancy Nichols, University of Reading, United Kingdom; *VolkerMehrmann*, Institut fur Geometrie und Praktische Mathematik, West Germany

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Tuesday, November 6/3:15 PM
MS19

Algebraic and Geometric Methods in Linear Systems Theory

This minisymposium will focus on the problem of parameterization of linear time invariant and linear time varying dynamical systems. In some cases explicit design problems involving stabilization of dynamical systems by dynamic output feedback have been considered. In particular the speakers consider algebraic methods in stabilizing time varying systems, high gain and dynamic compensation and system degeneration problems. The message that the speakers convey in this minisymposium is that - algebraic and geometric methods in system theory play a distinctive role in application areas like linear system identification and adaptive control.

Organizer: Bijoy Ghosh
Washington University

Coefficient Assignment of Time-Varying Systems: A New Technique
Paul R. Bouthellier, Washington University

Convergence Analysis of Linear Dynamical Systems by High Gain and High Dynamic Compensation
To be presented by organizer

Robust Estimation of Time-Varying Parameters in Linear Systems
Edward Kamen, University of Pittsburgh

A Compactification of the Space of Multivariable Linear Systems Using Geometric Invariant Theory
Joachim Rosenthal, University of Notre Dame

Tuesday, November 6/3:15 PM
MS20

Bezoutians and Matrix Equations

This minisymposium deals with linear and quadratic matrix equations. The significance of these equations in various classical problems of mathematics and engineering is well known. Some recent developments have discovered the basic role these equations play in inverse problems and in interpolation problems for rational matrix functions. In a parallel development new insights into the theory of matrix equations have been achieved using the concept of Bezout operators for matrix polynomials and more general matrix valued functions. The present minisymposium will cover the underlying recent developments and their interrelations.

Organizer: L. Lerer
Technion - Israel Institute of Technology, Israel

Definite Solutions X, Y of the Equation AX=YB
Peter Lancaster, University of Calgary, Canada

Matrix Equations and Interpolation Problems for Rational Matrix Functions
Leiba Rodman, The College of William and Mary

A General Concept of Bezout Operators and Matrix Equations
To be presented by organizer

Bezout Operators for Entire Matrix Valued Functions and Applications
I. Haimovici, Technion - Israel Institute of Technology, Israel

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Tuesday, November 6/3:15 PM
MS21

Large-Scale Systems

Large-scale systems has been an active area of research in control and systems theory for some time. Techniques such as model reduction, decentralized control, etc. have been developed to deal with the complexity of very large problems that arise in the design of large space structures, control of power systems, etc. Research in this area is now taking a new direction to take advantage of the powerful computing power provided by the existing and forthcomingmulti-processors and supercomputers. World-experts who have been contributing to the research in this area for many years will give presentations in this minisymposium on the current and future trends in large-scale systems.

Organizer: Biswa N. Datta
Northern Illinois University

Low-Order Design and High-Order Simulation of Active Closed-Loop Control of Aerospace Structures
Mark J. Balas, University of Colorado, Boulder

Expanding Construction of Large-Scale Servosystems
Xiang-Ling Tan, Santa Clara University, and Masao Ikeda, Kobe University, Japan

Title to be included in the final program
Y. Ohkami, National Aerospace Laboratory, Japan

Closed Form Solutions to Lyapunov Equations and Application to Covariance Control
Kazunori Yasuda, Kobe University, Japan, and *Robert Skelton*, Purdue University

Title to be included in the final program
E.J. Davison, University of Toronto, Canada

Title to be included in the final program
E. Polak, University of California, Berkeley

Wednesday, November 7/10:30 AM
MS22

Matrix Equations and Applications to Control

The matrix equations: AX + XA = (Lyapunov) AX + XB = C (Sylvester) AXB - X = V (Stein) AX + XB - XCB = D (Riccati) and their discrete counter parts arise in various practical situations, including the study of boundary value problems in PDE, in sensitivity analysis of control systems, and in the study of optimal control.

Because of their importance, they have been well studied, both from theoretical and computational view points. There are, however, aspects of matrix equations that need careful attention and active research is still going on.

In this session, the speakers will present results of investigations on generalized Lyapunov theory, study of inertia of certain block matrices arising in linear systems via matrix equations and certain observer matrix equations.

Organizer: Karabi Datta
Northern Illinois University

Inertia of Certain Block Matrices Arising in Linear System
David H. Carlson, San Diego State University

Extensions of Lyapunov's Theorem
Man Kam Kwong, Argonne National Laboratory

The Matrix Equation BXA - X = R and Applications
To be presented by organizer

Wednesday, November 7/10:30 AM
MS23

The Total Least Squares Problem: Analysis, Applications and Generalizations

Every linear parameter estimation problem gives rise to an overdetermined set of linear equations AX = B. Whenever errors occur in both matrices A and B, Total Least Squares (TLS) is appropriate for solving this set and amounts to fitting a "best" subspace to the measurement data. Although the TLS concept is quite old, it has only recently attracted interest outside of statistics. Golub and Van Loan introduced the method into numerical analysis and first presented a SVD analysis of the problem. Since then, TLS has been successfully applied in a broad class of disciplines such as signal processing, system identification, frequency estimation, etc. This minisymposium surveys the TLS problem: after a description of its basic principle, the numerical, algebraic and statistical properties of the problem will be reviewed, as well as its computational aspects and merits. Furthermore, generalizations of the problem will be presented, as well as its practical use in signal processing.

Organizer: Sabine Van Huffel
Katholieke Universiteit Leuven, Belgium

Formulation and Analysis of the Total Least Squares Problem
Gene H. Golub, Stanford University

Properties and Computational Aspects of the Total Least Squares Problem
To be presented by organizer

Geometric Interpretation and Generalization of the Total Least Squares Problem
Bart De Moor, Katholieke Universiteit Leuven, Belgium

Practical Use of the Total Least Squares Problem in Signal Processing
Richard Roy, Stanford University

Wednesday, November 7/10:30 AM
MS24

Geometric Aspects of the Matrix Riccati Equation

The first talk in this minisymposium surveys geometric methods for the analysis of the algebraic Riccati equation. In the two following talks the dynamical behavior of Kalman filtering algorithms is studied when the parameters are allowed to take arbitrary (possibly misaligned) values. Then the algorithms may either converge or exhibit chaotic dynamical behavior. In the last talk the algebraic Riccati inequality is studied in the context of stochastic realization theory.

Organizer: Anders Lindquist
Royal Institute of Technology, Sweden

MINISYMPOSIA

Geometry of Discrete and Continuous Riccati Equations
Clyde Martin, Texas Tech University

Predictable and Unpredictable Dynamical Behavior of Kalman Filtering Algorithms I
Christopher I. Byrnes, Washington University

Predictable and Unpredictable Dynamical Behavior of Kalman Filtering Algorithms II
Yishao Zhou, Royal Institute of Technology, Sweden

Stochastic Realization, Noncausal Estimation and the Algebraic Riccati Inequality
Giorgio Picci, Universita di Padova, Italy

Wednesday, November 7/10:30 AM
MS25

Numerical Methods in Signals, Systems and Control (Part 2 of 2)

(see previous description on page 9, Minisymposium 18)

Organizer: Ralph Byers
University of Kansas

A Gradient Method for Computing the Optimal H infinity Norm
Pradeep Pandey, Charles Kenney, Alan Laub and Andrew Packard, University of California, Santa Barbara

Conjugate Gradient Type Methods for Solving Large Lyapunov Equations
Youcef Saad, NASA Ames Research Center

The Lanczos Expansion and Controllability/ Observability
Daniel L. Boley, University of Minnesota, Minneapolis, and Gene H. Golub, Stanford University

An Algorithm for the Computation of the Distance of a System from the Nearest Uncontrollable System
George Miminis, Memorial University of Newfoundland, Canada

Wednesday, November 7/10:30 AM
MS26

Structured Matrix Problems in Signals, Systems and Control (Part 1 of 2)

Matrix problems arising in control or signal processing very often have a special structure. In some cases the structure arises mainly in the areas of signals, systems and control, for example, linear systems with Toeplitz coefficient matrices, or eigenproblems for Hamiltonian or quaternion matrices.

In other cases the structure is common to other areas of application also, for example, sparsity.

In both cases it is desirable to develop numerical methods for the solution of such problems which are not only numerically stable but also respect the algebraic structure of the problem. Often the algebraic structure forces the solution to lie on a certain manifold or in a certain region. Numerical methods which do not preserve the algebraic structure can cause the solutions to wander from the required manifolds or out of the regions and can therefore be more sensitive to rounding errors than structure preserving methods. Moreover the structure exploiting methods are often more efficient than general methods. These two minisymposia present some results and analyses on such numerically stable and structure preserving methods.

Organizer: Sven Hammarling, Numerical Algorithms Group Ltd., United Kingdom

The Prolate Matrix: A Good Toeplitz Test Example
James M. Varah, University of British Columbia, Canada

Solving Sparse Linear Systems With Sparse Backward Error
Mario Arioli, CERFACS, France; Iain Duff, Harwell Laboratory, United Kingdom; *James Demmel*, University of California, Berkeley

Updating Rank-Revealing Orthogonal Factorizations and an Application in Signal Processing
Christian H. Bischof, Argonne National Laboratory; *Gautam M. Shroff*, Rensselaer Polytechnic Institute

Construction of Orthogonal Polynomials and Fast QR Factorization of Vandermonde-like Matrices
Lothar Reichel, University of Kentucky, Lexington

Wednesday, November 7/3:15 PM
MS27

Parameter Identification and Observability

Parameter identification and related questions of observability are fundamental in the design and analysis of systems and controls. The importance of these problems continues to motivate the development of mathematical tools for their solution. This session focuses on some recently developed analytical and numerical techniques for parameter identification and on some mathematical questions that have arisen in these problems.

Organizer: Gregory Ammar
University of Kentucky, Lexington

Identification, Gaussian Quadrature and Error Estimation
Clyde F. Martin and *Mark Stamp*, Texas Tech University

Estimation of Motion and Shape Parameters of a Rigid Body from its Orthogonal and Perspective Projections
Bijoy Kumar Ghosh, Washington University

Inverse Parabolic Problems and Discrete Orthogonality
J.R. Lund, Montana State University; C.F. Martin and *D.S. Gilliam*, Texas Tech University

Fully Sinc-Galerkin Recovery of Parameters in Parabolic Problems
John Lund and *Kenneth L. Bowers*, Montana State University

Wednesday, November 7/3:15 PM
MS28

Advanced Geometric Techniques

The goal of this minisymposium is to present applications of geometric techniques to some non-classical situations, such as periodic time varying systems, systems over rings, parameter dependent families of systems, and infinite-dimensional systems. In extending to such systems geometric notions and methods previously developed for linear finite dimensional systems, one encounters various problems whose solutions provide, in general, a better understanding of the system structure. The focus will therefore be on the definition and construction of suitable geometric objects and on the study of their properties, especially from an algebraic and module theoretic point of view, as well as on their use in specific applications to several control problems.

Organizer: G. Conte
University of Genova, Italy

Ring and Modules for Linear Systems - Attempts at a Synthesis
Michael K. Sain, University of Notre Dame; *Bostwick Wyman*, The Ohio State University, Columbus

Geometric Methods for Noninteracting Control of Linear Periodic Discrete-Time Systems
Osvaldo Maria Grasselli, Seconda Universita di Roma "Tor Vergata", Italy; *Sauro Longhi*, Universita di Ancona, Italy

Zeros at Infinity for Some Infinite Dimensional Systems with Unbounded State Operator
M. Malabre, Laboratoire d' Automatique de Nantes, France; *R. Rabah*, Universite d' Oran Essenia, Algeria

Geometric Methods in the Robust Disturbance Decoupling Problem
A.M. Perdon, Universita di Padova, Italy, and *G. Conte*, University of Genova, Italy

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Wednesday, November 7/3:15 PM
MS29

Numerical Aspects of Optimal Control

Optimal control problems are infinite dimensional optimization problems involving both a differential equation constraint and inequality constraints. Mathematical programming techniques can be applied to these problems, however, the infinite dimensional structure of the underlying spaces and constraints leads to interesting numerical issues.

Organizer: William W. Hager
University of Florida, Gainesville

Augmented Gradient Projection Methods for Constrained Regulator Problems
Joseph C. Dunn, Montana State University

Pointwise quasi-Newton Methods for Optimal Control Problems
Ekkehard W. Sachs, Universitat Trier, West Germany; *C.T. Kelley*, North Carolina State University

Mesh Independence of the Gradient Projection Method for Optimal Control Problems
C. Tim Kelley, North Carolina State University; *Ekkehard W. Sachs*, Universitat Trier, West Germany

Sensitivity in Optimal Control
Asen L. Dontchev, Bulgarian Academy of Sciences, Bulgaria, and *William W. Hager*, University of Florida, Gainesville

Multiplier Continuation Methods for Nonlinear Optimal Control
Audrey B. Poore, Colorado State University, and William W. Hager, University of Florida, Gainesville

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Wednesday, November 7/3:15 PM
MS30

Large-Scale and Parallel Matrix Computations (Part 1 of 2)

There have been some fine developments in the area of large-scale and parallel matrix computations in recent years. Powerful tools have now been developed to solve large and sparse linear systems, to compute selected eigenvalues of large and sparse matrices, and to solve other numerical linear algebra problems. Many of these algorithms for large and sparse matrices have been parallelized and/or vectorized and the vectorized and parallelized versions have been implemented on the existing multiprocessors. Extensive research is presently being carried out in many parts of the world.

This minisymposium is part 1 of the two sessions that have been organized to give the audience a broad overview of some of the current activities in this area with a hope that the researchers in control and systems theorists and practising engineers can profitably use these existing parallel numerical linear algebra tools to solve large and sparse problems in control. These two sessions are meant to be complimentary to Part 1 of the short course on "Large-Scale and Parallel Computations in Control, Systems and Signal Processing" that precedes the conference.

Organizer: Biswa N. Datta
Northern Illinois University

Orthogonal Factorizations of Rank-Deficient Matrices on High-Performance Architectures
Christian H. Bischof, Argonne National Laboratory

A Rank Revealing QR Factorization for Large Sparse Matrices
Dan Peirce and *John G. Lewis*, Boeing Computer Services

The k-Step Arnoldi Method
Danny C. Sorensen, Rice University

Linear Algebra on a Massively Parallel Computer
Robert Schreiber, RIACS-NASA Ames Research Center

Wednesday, November 7/3:15 PM
MS31

Linear Algebra on Multiprocessor Systems

The development and use of parallel algorithms on current high-performance computers is becoming, more and more, an important factor in Control Theory and Signal Processing research. Numerical Linear Algebra is an indispensable tool in such research. The speakers in this minisymposium will explore some recent developments in Numerical Linear Algebra. These include the design of parallel algorithms for solving linear systems which arise in the Super-Resolution of SAR images, the numerical solution of PDE, the computation of the SVD or solving Sparse Linear Systems. Shared-Memory Machines and Distributed-Memory Multicomputers are two alternative architectures used to solve these kinds of problems efficiently.

Co-Organizers: Vicente Hernandez
Universidad Politecnica de Valencia, Spain
and Mateo Valero, Universidad Politecnica de Cataluna, Spain

Parallel Algorithms for Sparse Matrices
Iain S. Duff, Rutherford Appleton Laboratory, United Kingdom

Parallel Super-Resolution of Synthetic Aperture Radar Images
L.M. Delves, University of Liverpool, United Kingdom

Parallel Grid-Based PEE-Algorithms for Distributed Memory-Architectures
Karl Solchenbach, Application Software, West Germany

Parallel Computation of the Singular Value Decomposition on a Distributed Memory Multiprocessor
Vicente Hernandez, and *Antonio M. Vidal*, Universidad Politecnica de Valencia, Spain

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Thursday, November 8/10:45 AM
MS32

Performance Analysis for SVD-Based Signal Processing

The last decade has seen a veritable explosion in the number of signal processing algorithms that use singular value decomposition (SVD) to obtain robust separation of signal from noise. The first applications of SVD in signal processing were in system identification (1978), direction finding (1979), harmonic retrieval (1982), and parametric spectral analysis (1984). New applications are even being found for the SVD in computer vision problems. In addition, much of the SVD-related research in the signal processing community is focussed on analyzing the performance of these algorithms, and identifying fundamental limits on their performance. Three of the talks in this minisymposium will be on performance analysis of SVD-based algorithms for narrow-band direction finding with sensor arrays. Statistical techniques, first order perturbation analysis, and asymptotic analysis will be discussed. The fourth talk will present a new and exciting application of SVD in simultaneous structure extraction and motion estimation from a sequence of image frames.

Organizer: K.S. Arun
University of Illinois, Urbana-Champaign

Performance Analysis of State-Space Based Direction Finding Algorithms
Bhaskar D. Rao, University of California, San Diego

Asymptotic Analysis of SVD-Based Array Processing Algorithms
Bjorn Ottersten, Linkoping University, Sweden

A Perturbation Theorem for Sensitivity Analysis of SVD Based Algorithms
Yingbo Hua, University of Melbourne, Australia, and *Tapan Sarkar*, Syracuse University

An SVD-Based Algorithm for 3D Structure and Motion Estimation
Chris DeBrunner, University of Illinois, Urbana-Champaign

Thursday, November 8/10:45 AM
MS33

Asynchronous Iterative Methods: Theory and Practice

The efficient implementation of asynchronous iterative methods for a wide variety of large scale computation problems is now the subject of much research. In particular, asynchronous implementations, in which computation and communication are performed independently in each processor, are attractive on account of several potential advantages such as reduction of processor idle times, shorter time to convergence, simpler programming and so on. This minisymposium will address both theoretical issues such as rates of convergence of synchronous algorithms as well as practical issues such as implementation on specific parallel architectures, choice of matrix partitions and splittings to accelerate convergence etc. The application areas range from power systems to network flow cost minimization problems.

Co-organizers: Amit Bhaya and Eugenius Kaszkurewicz, Federal University of Rio de Janiero, Brazil

Asynchronous Teams
Sarosh N. Talukdar and Chung-Lung Chen, Carnegie Mellon University

On the Rate of Convergence of Partially Asynchronous Algorithms
Paul Tseng, Massachusetts Institute of Technology

Asynchronous Block Iterative Methods for Almost Linear Equations
Amit Bhaya, *Eugenius Kaskurewicz* and Francisco Mota, Federal University of Rio de Janeiro, Brazil

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Thursday, November 8/10:45 AM
MS34

Structured Matrix Problems in Signals, Systems and Control (Part 2 of 2)

Matrix problems arising in control or signal processing very often have a special structure, for example, Hamiltonian or quaternion methods for the solution of these problems which not only are numerically stable but also preserve the algebraic structure of the problem. Usually the algebraic structure forces the solution to lie on a certain manifold or in a certain region. Numerical methods which do not preserve the algebraic structure can cause the solutions to wander off the required manifolds or out of the regions, and therefore, can be more sensitive to rounding errors than structure preserving methods. Moreover, the structure preserving methods are often more efficient than general methods. This minisymposium presents some recent results on such numerically stable and structure preserving methods.

Organizer: Angelika Bunse-Gerstner
Universitat Bielefeld, West Germany

Reducing J-symmetric Matrices
Kresimir Veselic, Fernuniversitat Hagen, West Germany

Generalizations of Byer's Hamiltonian QR algorithm
David S. Watkins, Washington State University

Numerical Methods for Simultaneous Diagonalization
Angelika Bunse-Gerstner and Volker Mehrmann, Universitat Bielefeld, West Germany; *Ralph Byers*, University of Kansas

Discrete Least Squares Approximation by Trigonometric Polynomials
William B. Gragg, Naval Postgraduate School; Lothar Reichel and *Gregory S. Ammar*, University of Kentucky

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Thursday, November 8/10:45 AM
MS35

Stochastic Models and Control

Stochastic models are used in the modelling of many physical phenomena. Often it is necessary to control these stochastic models. The control may be for known systems, optimal control, or it may be for unknown systems, adaptive control. In this minisymposium, stochastic models are considered for some physical phenomena and the optimal control as well as the adaptive control of stochastic systems are considered.

Organizer: T.E. Duncan
University of Kansas

Osterwalder-Schrader Processes and Their Relation to Markov Processes
Sanjoy K. Mitter, Massachusetts Institute of Technology

Interruptible Prices for Electrical Power
Chin-Woo Tan and Pravin Varaiya, University of California, Berkeley

Anticipative Stochastic Control
G. Burstein and M.H.A. Davis, Imperial College, United Kingdom

Some Quadratic Functionals and Self-tuning Control for Stochastic Evolution Models
B. Pasik-Duncan and *T.E. Duncan*, University of Kansas

Thursday, November 8/10:45 AM
MS36

Singular Systems

Jacobi methods for solving the eigenproblem are now enjoying a growing interest. This is due to the possibilities they offer on parallel architectures. A newly discovered feature of Jacobi methods is the fact that they can compute the eigensolution with relatively high accuracy, a property not shared by any method based on previous tridiagonalization. Both aspects could compensate the traditional shortcoming of the Jacobi method, namely its efficiency which is not drastically, but sensibly under that of the methods based on previous tridiagonalization. The

(Minisymposia continued on page 14)

PROGRAM-AT-A-GLANCE

	Sunday, November 4	Monday, November 5
7:30		**Registration Desk Opens**
8:00	**Registration for Short Course**	
8:15	**Overview and an Introduction to Numerical Solutions of Small and Dense Linear Control Problems** Biswa N. Datta	**Welcoming Remarks:** Biswa N. Datta
8:30		*IP1* **Geometric and Lie Theoretic Methods for Inverse Eigenvalue Problems Arising in Control** Christopher Byrnes
8:45		
9:00	**Part I: Techniques of Large-Scale and Parallel Matrix Computations**	
9:15		*IP2* **On Hankel Operators, Bezoutians and Algebraic Stability Criteria** Paul A. Fuhrman
9:30	**Parallel Algorithms for Dense Matrix Computations** Ahmed Sameh	
9:45		
10:00	**Coffee**	**Coffee**
10:15		
10:30	**Parallel Algorithms for Sparse Matrices** Iain Duff	CONCURRENT SESSIONS *MS1* **Periodic Systems and Control** Chair: Sergio Bittanti *MS2* **Mathematical Methods in Signal Processing** Chair: James R. Bunch *MS3* **Singular Systems and Control** Chair: Stephen L. Campbell *MS4* **Observability and Linear Systems** Chair: Clyde Martin *MS5* **Matrix Polynomials and Rational Functions (Part 1 of 2)** Chair: Leiba Rodman *MS6* **Numerical Eigen-Assignment** Chair: Biswa N. Datta *CP1* **Matrix Theory 1**
10:45		
11:00		
11:15		
11:30	**An Overview of Krylov Subspace Methods and Applications to Control** Youcef Saad	
11:45		
12:00		
12:15		
12:30	**Lunch**	**Lunch**
12:45		
2:00	**Part II: Applications** **Large-Scale and Parallel Computations in Control** Biswa N. Datta	CONCURRENT *IC1* **Robust Stability of Interval Dynamic Systems** S.P. Bhattacharyya *IC2* **Matrix Completion Problems** Charles R. Johnson *IC3* **Comparison of Adaptive Condition Estimators in Control and Signal Processing** Robert J. Plemmons
2:15		
2:30		
2:45		**Coffee**
3:00		
3:15		GONCURRENT SESSIONS *MS7* **Systems and Behaviors** Co-chairs: A.C. Antoulas and J.M. Schumacher MS8 **Iterative Methods and Algorithms** Chair: David Kincaid *MS9* **Singular Systems** Chair: Volker Mehrmann *MS10* **Matrix Polynomials and Rational Functions (Part 2 of 2)** Chair: Leiba Rodman *MS11* **Parallel Computations in Optimal Control** Chair: Biswa N. Datta *CP2* **Robust H_∞ and Decentralized Control** *CP3* **Numerical Methods in Signal Processing** *5:00 PM Registration Desk Closes
3:30	**Coffee**	
3:45		
4:00	**Mapping of Kalman Filtering Onto Parallel Architectures** R.S. Baheti	
4:15		
4:30		
4:45		
5:00	**Discussion**	
5:15		
5:30	**Short Course Adjourns**	
5:45		
6:00		**SIAM Idea Exchange**

**Codes in italics designate session numbers for invited presentations, plenary (IP) and concurrent (IC), minisymposia (MS) and contributed presentations (CP).*

Tuesday, November 6	Wednesday, November 7	Thursday, November 8
Registration Desk Opens	**Registration Desk Opens**	**Registration Desk Opens**
IP3 **Least Squares and Restricted Least Squares: Problems, Methods, and Applications** Ake Bjorck	*IP5* **Computational Circuits for Upper Operators** Patrik Dewilde	*IP7* **Decentralized Control and Computation** Dragoslav D. Siljak
IP4 **Max-Scaling of Matrices and Weighted Graphs** Hans H. Schneider	*IP6* **Recent Developments in Robust and H$^\infty$ Control Theory** Pramod P. Khargonekar	*IP8* **Linear Algebra in Sensor Array Signal Processing** Thomas Kailath
Coffee	**Coffee**	**Closing Remarks**
		Coffee
Poster Session *MS12* **Stohastic and Structured Systems** Chair: A. Bagchi *MS13* **Problems in Linear Systems** Chair: Stephen Barnett *MS14* **Fast Algorithms for Toeplitz Matrices (Part 1 of 2)** Co-chairs: Adam W. Bojanczyk and Franklin T. Luk *MS15* **Inverse Eigenvalue Problems and Linear Systems** Chair: Christopher I. Byrnes *MS16* **Parallel Computations in Linear Control** Chair: Biswa N. Datta *CP4* **Numerical Linear Algebra 1**	CONCURRENT SESSIONS *MS22* **Matrix Equations and Applications to Control** Chair: Karabi Datta *MS23* **The Total Least Squares Problem: Analysis, Applications and Generalizations** Chair: Sabine Van Huffel *MS24* **Geometric Aspects of the Matrix Riccati Equation** Chair: Anders Lindquist *MS25* **Numerical Methods in Signals, Systems and Control (Part 2 of 2)** Chair: Ralph Byers *MS26* **Structured Matrix Problems in Signals, Systems and Control (Part 1 of 2)** *CP7* **Nonlinear Control**	CONCURRENT SESSIONS *MS32* **Performance Analysis for SVD-Based Signal Processing** Chair: K.S. Arun *MS33* **Asynchronous Iterative Methods: Theory and Practice** Co-chairs: Amit Bhaya and Eugenius Kaskurewicz *MS34* **Structured Matrix Problems in Signals, Systems and Control (Part 2 of 2)** Chair: Angelika Bunse-Gerstner *MS35* **Stochastic Models and Control** Chair: T.E. Duncan *MS36* **Singular Systems** Chair: Kresemir Veselic *CP10* **Numerical Methods in Control**
Lunch	**Lunch**	**Lunch**
CONCURRENT *IC4* **Algebraic Foundations for the Theory of Singular Linear Systems** Bostwick F. Wyman *IC5* **High Accuracy Algorithms in LAPACK** James Demmel *IC6* **Stability and D-Stability** Daniel Hershkowitz	CONCURRENT *IC7* **Generalizations of the Ordinary Singular Value Decomposition: Structure, Properties and Applications** Bart L.R. De Moor *IC8* **Stability and Control of Small-Signal Behavior in Power Systems** George C. Verghese *IC9* **Linear Controller Design Via Non differentiable Convex Optimization** Stephen Boyd	CONCURRENT *IC10* **Hessenberg and Block-Hessenberg Forms in Linear System Theory** R.V. Patel *IC11* **Steepest Descent Problems and the Toda Lattice** Anthony M. Bloch IC12 **Linear Algebra in Wavelet Algorithms** George Cybenko
Coffee	**Coffee**	**Coffee**
CONCURRENT SESSIONS *MS17* **Fast Algorithms for Toeplitz Matrices (Part 2 of 2)** Co-chairs: Adam W. Bojanczyk and Franklin T. Luk *MS18* **Numerical Methods in Signals, Systems and Control (Part 1 of 2)** Chair: Ralph Byers *MS19* **Algebraic and Geometric Methods in Linear Systems Theory** Chair: Bijoy Ghosh *MS20* **Bezoutians and Matrix Equations** Chair: L. Lerer *MS21* **Large-Scale Systems** Chair: Biswa N. Datta *CP5* **Periodic and Optimal Control** *CP6* **Parallel Matrix Computations** ***5:00 PM Registration Desk Closes**	CONCURRENT SESSIONS *MS27* **Parameter Identification and Observability** Chair: Gregory Ammar *MS28* **Advanced Geometric Techniques** Chair: G. Conte MS29 **Numerical Aspects of Optimal Control** Chair: William W. Hager *MS30* **Large-Scale and Parallel Matrix Computations (Part 1 of 2)** Chair: Biswa N. Datta *MS31* **Linear Algebra on Multiprocessor Systems** Co-chairs: Vicente Hernandez and Mateo Valero *CP8* **Linear Control Systems** *CP9* **Matrix Theory 2** ***5:00 PM Registration Desk Closes**	***3:30 PM Registration Desk Closes** CONCURRENT SESSIONS *MS37* **Shorted Operators** Chair: Tsuyoshi Ando *MS38* **Interpolation and Extension Problems for Matrix Functions** **Chair: M.A. Kaashoek** *MS39* **Algebraic Approach to Nonlinear Control** Chair: Madan Verma *MS40* **Large-Scale and Parallel Matrix Computations (Part 2 of 2)** Chair: Biswa N. Datta *MS41* **Linear Algebra in Systolic Arrays** Co-chairs: Mateo Valero and Vicente Hernandez *CP11* **Numerical Linear Algebra 2**
		Conference Adjourns

**Codes in italics designate session numbers for invited presentations, plenary (IP) and concurrent (IC), minisymposia (MS) and contributed presentations (CP).*

MINISYMPOSIA

minisymposium will therefore focus its attention to those questions as well as to some particularities on the convergence theory.

Organizer: Kresimir Veselic
Fernuniversitat Hagen, West Germany

A Real Jacobi-Type Algorithm Using Orthogonal Transformations to Obtain Real Schur Form for Non-Symmetric Matrices
M. Mantharam and *P.J. Eberlein*, SUNY-Buffalo

Jacobi's Method is More Accurate Than QR
Kresimir Veselic, Fernuniversitaet Hagen, West Germany; *James Demmel*, University of California, Berkeley

On the Generalized Schur Decomposition of a Matrix Pencil for Parallel Computation
Heike Fasbender and *Angelika Bunse-Gerstner*, Universitat Bielefeld, West Germany

Asymptotic Behavior of Jacobi Methods
Vjeran Hari, University of Zagreb, Yugoslavia and University of Kansas

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Thursday, November 8/3:30 PM
MS37

Shorted Operators

The operation of making a shorted operator from a positive semidefinite matrix (or operator) is closely connected with parallel addition in studying parallel connection of multisports resistive networks. A shorted operator itself corresponds to a short of a network while the familiar Schur complement in a matrix theory is a shorted operator. Shorted operators are related also to matrix Riccati equations. The notion of shorted operators is quite useful in qualitative and quantitative descriptions of extreme points of certain convex sets of Hermitian matrices. Starting with an overview, this minisymposium will cover the roles of shorted operators and their generalizations in certain extremal problems and in exact descriptions of their solutions.

Organizer: Tsuyoshi Ando
Hokkaido University, Japan

Shorted Operators—an Overview
William N. Anderson Jr., Fairleigh Dickinson University; William Green and Thomas Morley, Georgia Institute of Technology; *George Trapp*, West Virginia University

Extremal Problems and the Shorted Operator
William N. Anderson, Jr., Fairleigh Dickinson University

Parametrization in Terms of Shorted Operators
To be presented by organizer

Shorted Operators onto Operator Ranges and Its Applications
Edvard Leonidovich Pekarev, Odessa Technical Institute for Food Industry, USSR

Thursday, November 8/3:30 PM
MS38

Interpolation and Extension Problems for Matrix Functions

Various problems in signal processing, control and system theory may be recasted as interpolation problems for matrix functions or as extension problems for partially given operators. In this setting one of the main interpolation problems is to reconstruct a rational matrix function from partial information about its poles/zeros and corresponding directional vectors. The first two lectures are the last concerned with different aspects of this problem. The powerful reproducing kernel space techniques from the main topic of the third lecture; they provide a general method to solve matrix versions of Nevalinna-Pick and Caratheodory-Fejer type interpolation problems. The fourth paper presents the solution of a generalization of the Nehari distance problem via reduction to a Hankel extension problem, and the fifth paper concerns an eigenvalue completion problem.

Organizer: M.A. Kaashoek
Vrije Universiteit, The Netherlands

Interpolation by Rational Matrix Function with Minimal McMillan Degree
A.C. Antoulas, E.T.H. Zurich, Switzerland, and Rice University; J.C. Willems, University of Groningen, The Netherlands; J.A. Ball and *J. Kang*, Virginia Tech

Local Minimal Factorizations in Terms of Left Null-Pole Triples: Formulas for Factors
A.C.M. Ran, Vrije Universiteit, The Netherlands; L. Rodman, College of William and Mary

Interpolation by Reproducing Kernel Space Methods
H. Dym, Weizman Institute of Science, Israel

Minimal Norm Completions of Hankel Operators
J.W. Helton, University of California, San Diego; *H.J. Woerdeman*, University of California, San Diego

The Eigenvalues of Matrices with Given Upper Triangular Part
J.A. Ball, Virginia Polytechnic and State University; I. Gohberg, Tel-Aviv University, Israel; L. Rodman and *T. Shalom*, The College of William and Mary

Boundary Nevalinna-Pick Interpolation for Matrix Functions
J.A. Ball, Virginia Tech; I. Gohberg, Tel-Aviv University, Israel; and *L. Rodman*, The College of William and Mary

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Thursday, November 8/3:30 PM
MS39

Algebraic Approach to Nonlinear Control

Algebraic techniques and methods have played a significant role in the analysis and design of linear control systems. Thus investigating the applicability and scope of these methods for nonlinear systems is of interest. The aim of this minisymposium is to bring together form pioneers in this area who have approached this issue from different viewpoints. In their talks, these speakers will present the most recent developments and reflect on the current issues in this area. Some of the topics which are covered in their talks include input-output and fractional representations, stabilization, optimization and factorization of nonlinear systems.

Organizer: Madan Verma
McGill University, Canada

Fraction Representations and Robust Control of Nonlinear Systems
Jacob Hammer, University of Florida

Global Stabilization of Discrete-Time Nonlinear Systems
Bijoy Kumar Ghosh, Washington University

Nonlinear H-Infinity Control and Differential Game Theory
Joseph A. Ball, Virginia Tech

Factorization of Nonlinear Systems
Asher Ben-Artzi, *J. William Helton* and Hugo Woerdeman, University of California, San Diego

Parametrizing Stabilizing Controllers for Nonlinear Plants
To be presented by organizer

Thursday, November 8/3:30 PM
MS40

Large-Scale and Parallel Matrix Computations (Part 2 of 2)

(See overview, Minisymposium 30)

Organizer: Biswa N. Datta
Northern Illinois University

Tridiagonal Form and Minimal Realization
Beresford N. Parlett, University of California, Berkeley

Partitioning Large-Scale Irregular Grid Problems for Parallel Processing
Horst Simon, NASA-Ames Research Center

Efficient High Accuracy Solution with GMRES(m)
Kathryn Turner and *Homer F. Walker*, Utah State University

Thursday, November 8/3:30 PM
MS41

Linear Algebra in Systolic Arrays

Linear Algebra and Systolic Algorithms are tightly connected. On the one hand, a number of Systolic Algorithms for Linear Algebra Computations have been proposed in the literature. On the other hand, Linear Algebra is being used as a tool in Systolic Algorithms design methodologies. In this minisymposium, the speakers will review and propose systematic design methodologies for Systolic Algorithms. These methodologies can be used to implement application specific systolic array processors or to program versatile pseudosystolic arrays or even to program Distributed Memory Multiprocessors. Some of the topics that will be discussed by the speakers are: partitioning, grain size, communication topology, communication problems, etc. All the speakers will use examples of the Linear Algebra to illustrate their methods.

Co-organizers: Mateo Valero
Universidad Politecnica de Cataluna, Spain
and Vicente Hernandez,
Universidad Politecnica de Valencia, Spain

The Multi-Mesh-Graph (MMG) Method for Pseudo-Systolic Arrays
Jaime H. Moreno, Universidad de Concepcion, Chile; *Tomas Lang*, University of California, Los Angeles

Systolic Array Design in the Linear Algebra Framework
Jose A.B. Fortes, Purdue University

Design and Synthesis of Optimal 1D and 2D Systolic Arrays for Linear Algebra
Yves Robert, Ecole Normale Superieure de Lyon, France

Increasing Systolic Algorithm Granularity for Multicomputers
A. Fernandez, J.M. Llaberia, J.J. Navarro, M. Valero-Garcia, *M. Valero*, Universidad Politecnica de Cataluna, Spain

Contributed Presentations

Monday, November 5/10:30 AM
CP1
Matrix Theory Session 1

Sign Patterns that Require Real or Pure Imaginary Eigenvalues
Carolyn A. Echenbach, Georgia State University and Charles R. Johnson, College of William and Mary

Operator Means and Norm Convergence
Mohammad R. Khadivi, Jackson State University

On the Range of the Matrix Ajoint Operator
Charlie H. Cooke, Old Dominion University

Singular Interval Matrices
Jiri Rohn, Charles University, Czechoslovakia

Inverse Spectral Problems Related to Classical Lie Algebras and Realization Theory
Leonid Faybusovich, Harvard University

On the Global and Cubic Convergence of a Quasi-Cyclic Jacobi Method
Noah H. Rhee, University of Missouri, Kansas City and Vjeran Hari, University of Zagreb, Yugoslavia

Eigenvalue Estimates for Symmetric Matrices
Pablo Tarazaga, University of Puerto Rico, Mayaguez

Monday, November 5/3:15 PM
CP2
Robust H_∞ and Decentralized Control

Approximate Spectral Analysis of Markovian Point Processes
Bernard F. Lamond, University of Arizona

Zero Sets Methods in Robust Control
Gila Fruchter, Technion-Israel Institute of Technology, Israel

Stochastic Delay Differential Games
Kandethody M. Ramachandran, University of South Florida

Probabilistic Optimization with Demolition
Dean Zes, McDonnell Douglas Helicopter Company, Mesa, AZ

On H-two Optimal Controller Design with H-infinity Constraints
Nasser M. Khraishi and Abbas Emami-Naeini, Systems Control Technology, Inc., Palo Alto, CA

Decentralized Sliding Modes in Nonlinear Interconnected Dynamic Systems Output Tracking
Yu.B. Stessel and A.Yu. Evnin, Chelyabinsk Politechnical Institute, USSR

Systems of Coupled Algebraic Riccati Equations in H_2/H_∞ Robust Control
Dennis S. Bernstein, Harris Corporation, Melbourne, FL and Wassim M. Haddad, Florida Institute of Technology

A Sufficient Condition of a Solution of Riccati Equation in Practical Stabilization Problems
F. Hamano, California State University, Long Beach

Riccati Synthesis of Robust Control for Nominally Linear Plants
C.C. Blackwell, University of Texas, Arlington

Monday, November 5/3:15 PM
CP3
Numerical Methods in Signal Processing

The MUSIC of the Spheres
William H. Ludescher, GE Aerospace, Eagleville, PA

Nonlinear Estimation Without the Gaussian Assumption
Timothy Johnson and *Joohwan Chun*, General Electric Research & Development, Schenectady

A Class of Matrices with Special Properties of Benefit to some Signal Processing Algorithms
Francis LeRoy McWhorter, West Virginia Wesleyan College

A Survey of Neural Control
James Hinnant and *Rajab Challoo*, Texas A&I University

Reduced Order Covariance Extended Kalman Filters for Direction Cosine Matrix Estimation
Frank A. San Filippo, Rockwell International Corporation, Lakewood, CA

Numerically Stable Banded Toeplitz Solvers and Their Relationship to Wiener Filtering
Donald T. Gavel, Lawrence Livermore National Laboratory

Matrices Associated with Eigenspace Solutions to the Direction of Arrival Problem
Patrick L. Odell, Baylor University

Numerical Algorithm for Stability Testing and Margin of Stability of 2D Recursive Filters via Eigenvalue Computation
M Wang, E.B. Lee and *D. Boley*, University of Minnesota, Minneapolis

Backpercolation: On Exploiting the Duality Between Signals and Weights
Mark Jurik, Jurik Research, Aptos, CA

Tuesday, November 6/10:30 AM
CP4
Numerical Linear Algebra 1

A Constrained Newton Algorithm for Semilinear Models
Phillip L. Ainsleigh, Naval Research Laboratory, Orlando and James D. George, Signalmetrics, Inc., Winter Park, FL

A Direct Solution to Matrix Least-Squares Fitting with Constrained Singular Values
Juyang Weng, University of Montreal, Canada

Gauβ-Newton-Methods for Rank-Deficient Problems
Matthias Heinkenschloβ, Universitat Trier, West Germany and Rice University

Automatic Scaling of Equations and Unknowns
James Hurt, Hardy, Hurt and Coin, Cleveland

Computation of the Rank of Large Matrices Whose Entries Hold on 64 Bits
Yves de Montaudouin, IBM T.J. Watson Research Center

A Generalized Singular Value Decomposition Based ESPRIT Direction-of-Arrival Estimation Algorithm
Haesun Park, University of Minnesota, Minneapolis

Least Squares and Complementarity Problems Using Relaxation in Image Processing
Alvaro R. De Pierro, State University of Campinas, Brazil

A Modular Algorithm for Computing Hankel Matrix Ranks
J. Llovet and J.R. Sendra, Alcala de Henares University, Spain

Tuesday, November 6/3:15 PM
CP5
Periodic and Optimal Control

Matrix Gradient Method for State Space Modeling
William Edmonson and Winser Alexander, North Carolina State University

Finite-Difference Approximations for Linear Systems of Optimal Control
Boris S. Mordukhovich, Wayne State University

On Optimal Positioning of a Damper
K. Veselic, Fern Universitat, West Germany

A Convex Optimization Approach for Computing Structured Singular Values
Nasser M. Khraishi and Abbas Emami-Naeini, Systems Control Technology, Inc., Palo Alto, CA

Stable Planning
Sanjo Zlobec, McGill University, Canada

M-Periodic Controller for Maximum Gain Margin for NMP Discrete-Time Systems
Sarit K. Das and *P.K. Rajagopalan*, Indian Institute of Technology, India

The Invariant Formulation of Descriptor Discrete-Time Linear Periodic Systems
Vicente Hernandez, University Politecnica de Valencia, Spain and Teresa Pedroso de Lima, Universidad de Coimbra, Portugal

Numerical Solution to an Optimal Control Problem Arising in Fluid Flow
Thomas P. Svobodny, Wright State University

An Algorithm to Compute a Center of a Polytope
Eric A. Lord, Indian Institute of Science, India; V. CH. Venkaiah, Central Research Laboratory, Bharat Electronics, India; and S.K. Sen, SERC, Indian Institute of Science, India

Orthogonal l_1 Approximation for Parameter Estimation Using Karmarkar's Algorithm
M.R. Bhatt and *U.B. Desai*, Indian Institute of Technology, India

Tuesday, November 6/3:15 PM
CP6
Parallel Matrix Computations

Fourier Stieltjes Convolution in Parallel-A Unified Signal Algebra Approach
C.R. Giardina, City University of New York, Mahwah, NJ

The Application of Block Gaussian Elimination on the iPSC/860
David Scott, Enrique Castro-Leon, and Ed Kushner, Intel Scientific Computers, Beaverton, OR

Vectorization of Array Algebra Algorithms
C.T. Fulton and D.W. Fausett, Florida Institute of Technology

Incomplete Product Form Inverse Preconditioning Iterative Method
Tsun-Zee Mai, University of Alabama, Tuscaloosa

Solving Nonlinear Matrix Equations on Distributed Memory Computer Systems
Dingju Chen and Yizhong Wu, Cornell University

Contributed Presentations

Accelerators for Matrix Mathematics Using Parallelism
Roland Cooke and John Purviance, University of Idaho

An Inherently Parallel Algorithm for Matrix Computations
B. Fardanesh and T. Wu, Manhattan College

A New Downdating Algorithm and Its Implementationon a SIMD Machine
C.H. Bischof, *C.T. Pan* and P.T.P. Tang, Argonne National Laboratory

Applying Parallel Computer System to Solve Symmetric Tridiagonal Eigenvalue Problems
Xiangzhen Qiao, Academia Sinica, People's Republic of China and *Mi Lu*, Texas A&M University, College Station

Parallel Algorithms for the Observer Matrix Equation
Biswa Nath Datta and *A. Purkayastha*, Northern Illinois University

Wednesday, November 7/10:30 AM
CP7
Nonlinear Control

Symmetries and Nonlinear Feedback Design
Viswanath Ramakrishna, Washington University

Differential Algebra and Locally Left Invertibility
Guolin Pan, University of Connecticut, Storrs and D.J. Bell, UMIST, United Kingdom

General Method of Analysis and Synthesis Nonstationary Linear Systems
Victor A. Taft, Palo Alto, CA

Feedback Linearization of Nonlinear Descriptor Systems
Stephen R. Kaprielian and Janos Turi, Worcester Polytechnic Institute

Recent Results and Open Questions on Admissibility of Unbounded Control Operators
George Weiss, Virginia Polytechnic Institute

The Operator Carleson Measure Criterion for the Admissibility of Control Operators
Scott Hansen and George Weiss, Virginia Polytechnic Institute

Norm Restriction Reachability of Linear Systems in Banach Spaces
Jianxun He and Pengnian Chen, Xiamen University, People's Republic of China

Wednesday, November 7/3:15 PM
CP8
Linear Control Systems

New Structural Invariants of Linear Multivariable Systems
A. Saberi and H.K. Ozcetin, Washington State University

Conditions for the Equivalence of ARMAX and ARXSystems
Gary A. McGraw, Charles L. Gustafson and James T. Gillis, The Aerospace Corporation, Los Angeles

A Criterion for Absolute Stability in Control Systems with Infinite Delay
A.S.C. Sinha, Purdue University, Indianapolis

Relation Between Pole Assignment and LQ Regulator for Discrete Systems
A. Tamaraz, A.S. Arar and M.E. Sawan, Wichita State University

Deadbeat Control of Linear Multivariable Systems
Abbas Emami-Naeini, Systems Control Technology, Inc., Palo Alto, CA

On Necessary and Sufficient Condition for the Stability of Interval Systems
B. Shafai and K. Perev, Northeastern University

On the Singular Values of Principal Axis Realization Matrices
Gregory J. Maskarinec and *Prabhakara Rao Chitrapu*, Drexel University

The Geometry of Singular Systems
Uwe Helmke, University of Reqensburg, West Germany

Time-Varying Feedback Control of Linear Systems Under Input and Output Constraints
Grazyna A. Pajunen and Nurgun Erdol, Florida Atlantic University

Wednesday, November 7/3:15 PM
CP9
Matrix Theory 2

Are the Coefficients of A Polynomial Well-Conditioned Functions of Its Roots?
Frank Uhlig, Auburn University

Pairs of Nilpotent Matrices and 2D Characteristic Polynomials
E. Fornasini, G. Marchesini, and S. Zampieri, University of Padova, Italy

Parallel Polynomial Approximation of Matrix Functions
B. Codenotti and M. Leoncini, Instituto di Elaborazione dell'Informazione, Italy

The Average Parallel Complexity of Cholesky Factorization
B. Codenotti and *G. Resta*, Instituto di Elaborazione dell'Informazione, Italy

The Gap of the Graph of a Circulant Matrix
Javad F. Habibi, Muskingum College

On D-Stability and Strong D-Stability
Michael K.H. Fan, Georgia Institute of Technology and Cheng-Ching Yu, National Taiwan Institute of Technology, Republic of China

Applying Matrix Theory to Nonlinear Control Systems
F. Silva Leite, Universidade de Coimbra, Portugal

Thursday, November 8/10:45 AM
CP10
Numerical Methods in Control

Generalized Equal-Area Criterion: A Method for On-line Transient Stability Analysis
Abdolhossein (Farrokh) Rahimi, Macro Corporation, Mountain View, CA

Design of Controllers by the Gain Scheduling Technique
S.M. Shahruz, University of California, Berkeley and Berkeley Engineering Research Institute

Parallel Updating Algorithms for Identification and Control
Marc Moonen and Joos Vandewalle, ESAT Katholieke Universiteit Leuven, Belgium

On the Solution to Matrix Equation TA-FT=LC and Its Applications
Chia-Chi Tsui, City University of New York College of Staten Island

On the Numerical Inversion of Laplace Transform
Michel Nakhla, Carleton University, Canada

State Space Measures of Robustness of Pole Locations for Structured and Unstructured Perturbations
Jorge M. Martin, Naval Weapons Center, China Lake, CA

Balanced Model Reduction of Singular Systems
K. Perev and B. Shafai, Northeastern University

Balanced Realizations of Systems with Parameters by Using a Neural Approach
L. Fortuna, M. Lo Presti, and G. Nunnari, Universita' di Catania, Italy

Thursday, November 8/3:30 PM
CP11
Numerical Linear Algebra 2

Preconditioners for Toeplitz-Block Matrices
Tony Chan, University of California, Los Angeles and *Julia Olkin*, SRI International, Menlo Park, CA

The Hyperbolic Singular Value Decomposition and Applications
Adam W. Bojanczyk, Ruth Onn and Allan O.Steinhardt, Cornell University

Some Applications of the Rank Revealing QR Factorization
Tony F. Chan, University of California, Los Angeles and *Per Christian Hansen*, Technical University of Denmark

On the Numerical Solution of the Eigenvalue Problem for Banded, Symmetric Toeplitz Matrices
Jesse L. Barlow, Pennsylvania State University and *Susan L. Handy*, HRB Systems, Inc., State College, PA

Stable Perturbations of Nonsymmetric Matrices with Multiple Eigenvalues
James V. Burke, University of Washington and *Michael L. Overton*, Courant Institute of Mathematical Sciences, New York University

A Status Report on LAPACK—A Linear Algebra Library for High-Performance Computers
Sven Hammarling, Numerical Algorithms Group Ltd., United Kingdom

Condition Estimation for the Eigenproblem
Zhaojun Bai, University of Kentucky and James Demmel, University of California, Berkeley

A Modified Hermitian Jacobi Algorithm
Haesun Park, University of Minnesota, Minneapolis and Vjeran Hari, University of Zagreb, Yugoslavia

Generalized QR Factorization and Its Applications
Edward Anderson, *Zhaojun Bai* and Jack Dongarra, University of Tennessee, Knoxville

Poster Sessions

Tuesday, November 6/10:30 AM

A New Algorithm to Estimate the Best Toeplitz Approximation for Positive Definite Matrices
Satyanarayan S. Rao and *P. Raadhakrishnan*, Villanova University

Predictive Transform Detection: A Simple and Optimum Unification of Channel Modeling and Detection
Erlan H. Feria, College of Staten Island of the City University of New York

The Eigenvalue Method for the Order Determination of Autoregressive (AR) Processes
Guoliang Zeng, Arizona State University

Structure Driven Scheduling of Matrix Arithmetic
G.N. Srinivasa Prasanna and Bruce R. Musicus, Massachusetts Institute of Technology

A New Approach to the Computer-Aided Design of the Multivariable Linear Systems with Multi-Performance-Index
Jiangbo Liu and John Fendrich, Bradley University; and Xun Lei, Academia Sinica, People's Republic of China

A Comparison of Predictive Transform Estimation and Hybrid Estimation
Joseph R. Guerci, Grumman Corporation, Bethpage, NY

Numerical Stability of the Convolution
Daniela Calvetti, Stevens Institute of Technology

The Geometry of Displacement Structure
Kenneth R. Driessel, Idaho State University

Hotel Information

Cathedral Hill Hotel
Van Ness at Geary Street
San Francisco, CA 94109
(415) 776-8200

SIAM is holding a block of rooms at the Cathedral Hill Hotel. These rooms are being held on a first come, first served basis at $77/Single and $97/Double. These rooms will be held for our exclusive use until October 15, 1990. After this date, reservations will depend on availability.

We urge you to make your reservations as soon as possible. You may do so by calling (415) 776-8200, or by mailing in the Hotel Reservation Form located in the back of this program. When making your reservation via phone, please be certain to identify yourself as an attendee at the SIAM Conference on Linear Algebra to receive the discounted rate.

Late Arrival Policy: If you plan to check-in after 6:00 PM, you must guarantee your room for late arrival by making payment in advance for one night. Payment can be made by either AMEX, MasterCard, VISA, Diner's Club or check.

Check-In: Check-in time is 3:00 PM and check-out time is 1:00 PM. If you need to change or cancel your reservation, be certain to contact the hotel by 1:00 PM Eastern Time on your stated date of arrival to avoid any unnecessary charges.

Dining: The hotel has one restaurant, the Hilltop Room, which specializes in fine dining and continental cuisine. The restaurant is open Tuesday through Saturday from 5:30 PM to 10:30 PM. Prices range from $14.00 to $17.00. There is also a coffee shop that is open seven days a week from 6:00 AM to 11:00 PM. It serves breakfast, lunch, and dinner, and the prices range from $3.50 for breakfast to $15.00 for dinner. There are many restaurants within walking distance of the hotel that offer a variety of cuisines.

Parking: The Cathedral Hill Hotel offers complimentary parking for those attendees staying at the hotel. Attendees not staying at the hotel, however, can expect to pay an average of $15.00 per day for parking.

Weather

Temperatures in San Francisco seldom rise above 70 or fall below 40. Women are most comfortable with a light jacket or coat, or in a suit. Men's attire requires only light-to-medium-weight suits or sports clothes.

Transportation Information

By Air

American Airlines has been chosen as the official carrier for this conference. You can fly to San Francisco and save on travel from November 2 - 10, 1990 inclusive. American Airlines is offering you the services of their toll free convention reservation desk, as well as other discounts.

- Get 5% off any fare for which you qualify, including First Class and Ultra Saver fares.
  THE DISCOUNTS CAN RANGE FROM 40% - 70% OFF NORMAL COACH FARES

OR. . .for those of you who do not qualify for the above discounts.

- American Airlines will offer a minimum of 45% off regular coach fares. Passengers whose flights originate in Canada will be offered a 35% discount off full coach fares. Both of these rates require a 7 day advance purchase.

To make reservations for one of the above discounted fares:

- Call American Airlines Convention Desk at 1-800-433-1790 seven days a week from 8:00 AM to 11:00 PM Eastern Time. Be sure to mention the SIAM account number: S03Z0CN. American Airlines will arrange to mail your tickets to your home or office.
- For those of you using a corporate or university travel agent, you can still purchase your ticket through the local agents, just be sure to mention the above discounts to the agents. Your local agent can call the American Airlines Convention Desk to make your reservation. Please be sure that the agent uses the SIAM account number: S03Z0CN.

By Car

From the Airport: Take 101 North until the freeway splits. Go left towards the Golden Gate Bridge. Follow the Golden Gate Bridge signs to the end of the freeway until it becomes Franklin Street. Proceed five blocks to Post Street and turn right. Continue to the intersection of Van Ness Avenue and turn right. The Cathedral Hill Hotel garage entrance is in the middle of the block on Van Ness.

From Los Angeles: Take Highway 5 North to 580 West to the Bay Bridge. Take the Main Street exit on the right. Proceed to Market Street and turn left, and then take the first right onto South Van Ness to Van Ness Street. Follow Van Ness Street to Geary Street. The Cathedral Hill Hotel is on Van Ness Street at Geary Street.

Public Transportation

From the Airport: Several airport shuttle vans stop at the island on the arrival level of the airport. Lorries Airport Service and Super Shuttle depart every 20 minutes and cost approximately $10.00. A local taxi will cost approximately $25.00. (Prices quoted at press time.)

Car Rental

BUDGET-RENT-A CAR has been selected as the official car rental agency for this conference. The following rates will apply between November 2 - 10, 1990.

Type of Car	Daily Rate	Weekly Rate
Compact	$28	$129
Intermediate	$34	$169
Standard	$36	$179

Reservations
We encourage you to make an advance reservation, as on-site availability cannot be guaranteed. Make reservations by calling 1-800-772-3773. When making reservations, be sure to give the SIAM Rate Code: #VNR2/SIAM. You should also mention that you are attending the SIAM Conference on Linear Algebra, November 5 - 8, 1990 in San Francisco, in order to receive the indicated rates.

- Cars may be picked up at the San Francisco Airport at the Budget Car Rental desk located in the baggage claim area of the airport. You may also pick cars up at any downtown location as well as San Jose/Oakland/Monterey airports.
- Cars must be picked up and dropped off at the same location.
- You must be 21 years of age and have a valid U.S. or international driver's license.
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- The prices quoted do not include refueling services, tax, optional collision damage waiver, and personal accident insurance.

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Book SHELF

Optimization and Nonsmooth Analysis
Frank H. Clarke

Mathematical Reviews said of this book that it was "destined to become a classical reference," and SIAM is pleased to welcome it as the fifth in its Classics Series. This book has appeared in Russian translation and has been praised both for its lively exposition and its fundamental contributions. It first develops a general theory of nonsmooth analysis and geometry which, together with a set of associated techniques, has had a profound effect on several branches of analysis and optimization. It then applies these methods to obtain a powerful, unified approach to the analysis of problems in optimal control and mathematical programming.

This updated softcover version of *Optimization and Nonsmooth Analysis*, like the original, focuses upon the central issues in optimization such as existence, necessary conditions and sensitivity, and presents results of considerable generality concerning these issues.

Contents. Introduction and Preview; Generalized Gradients; Differential Inclusions; The Calculus of Variations; Optimal Control; Mathematical Programming; Topics in Analysis.

April 1990
308 pages / Softcover / ISBN 0-89871-256-4
List Price $28.50 / SIAM Member Price $22.80
Order Code CL05

Methods of Dynamic and Nonsmooth Optimization
Frank H. Clarke

This monograph presents the elements of a new unified approach to optimization based on "nonsmooth analysis," a term introduced in the 1970's by the author, who is considered a pioneer in the field. Based on a series of lectures given at a conference at Emory University in 1986, this volume presents its subjects in a self-contained and accessible manner. The topics treated here have been in an active state of development, and this work therefore incorporates more recent results than those presented in 1986.

The book focuses mainly on deterministic optimal control, the calculus of variations, and mathematical programming. In addition, it features a tutorial in nonsmooth analysis and geometry and demonstrates that the method of value function analysis via proximal normals is a powerful tool in the study of necessary conditions, sufficient conditions, controllability, and sensitivity analysis. The distinction between inductive and deductive methods, the use of Hamiltonians, the verification technique, and penalization are also emphasized.

Contents. Nonsmooth Analysis and Geometry; The Basic Problem in the Calculus of Variations; Verification Functions and Dynamic Programming; Optimal Control; References.

October 1989
90 pages / Softcover / ISBN 0-89871-241-6
List Price $15.75 / SIAM Member Price $12.60
Order Code CB57

LINPACK Users' Guide
Jack J. Dongarra, James R. Bunch, Cleve B. Moler, and G. W. Stewart

The authors of this carefully structured guide are the principal developers of LINPACK, a unique package of Fortran subroutines for analyzing and solving various systems of simultaneous linear algebraic equations and linear least squares problems.

This guide supports both the casual user of LINPACK who simply requires a library subroutine, and the specialist who wishes to modify or extend the code to handle special problems. It is also useful for classroom work.

The LINPACK programs are available on either 9-track tape or a PC MS-DOS diskette format, from International Mathematical and Statistical Libraries, 7500 Bellaire Boulevard, Houston, TX 77036. The cost is $75.00.

Contents. General Matrices; Band Matrices; Positive Definite Matrices; Positive Definite Band Matrices; Symmetric Indefinite Matrices; Triangular Matrices; Tridiagonal Matrices; The Cholesky Decomposition; The QR Decomposition; Updating QR and Cholesky Decompositions; The Singular Value Decomposition; References; Basic Linear Algebra Subprograms; Timing Data; Program Listings; BLA Listings.

1979
367 pages / Softcover / ISBN 0-89871-172-X
List Price $28.00 / SIAM Member Price $22.40
Order Code OT08

PLTMG: A Software Package for Solving Elliptic Partial Differential Equations—*Users' Guide 6.0*
Randolph E. Bank

This book is intended mainly for use as a reference manual for the PLTMG Software package. Brief descriptions of some of the main algorithms are included where required to make clear the meaning of input parameters and the resulting behavior of the code. References are included, listing the papers that provide theoretical explanations of most algorithms in the code.

PLTMG was developed for testing and verifying properties of various multigrid and adaptive local mesh refinement algorithms. This book contains an overview of the entire package and demonstrations of its elementary capabilities. Each major subroutine is documented in its own chapter for reference.

PLTMG is a package for solving a general class of scalar, parameter dependent, elliptic partial differential equations in general regions of the plane. The code is based on a continuous piecewise linear triangular finite element discretization, and uses adaptive local mesh refinement, multigrid iteration, and continuation techniques. The package includes a mesh generator and extensive color graphics.

Contents. Chapter 1: Introduction; Chapter 2: Subroutine PLTMG; Chapter 3: Subroutine TRIGEN; Chapter 4: Subroutine TRIPLT; Chapter 5: Subroutine GPHPLT; Chapter 6: Subroutine INPLT; Chapter 7: Subroutine PLTEVL; Chapter 8: Subroutine SKELTN; Chapter 9: Program ATEST; Chapter 10: Machine Dependent Routines; Chapter 11: Examples; Chapter 12: Test Problems; Bibliography; Index.

May 1990
164 pages / Softcover / ISBN 0-89871-255-6
List Price $22.50 / SIAM Member Price $18.00
Order Code FR07

A Survey of Lie Groups and Lie Algebras with Applications and Computational Methods
Johan G.F. Belinfante and Bernard Kolman

This monograph introduces the concepts and methods of the Lie theory in a form accessible to the nonspecialist by keeping mathematical prerequisites to a minimum. Although the authors have concentrated on presenting results while omitting most of the proofs, they have compensated for these omissions by including many references to the original literature. Their treatment is directed toward the reader seeking a broad view of the subject rather than elaborate information about technical details. Illustrations of various points of the Lie theory itself are found throughout the book in material on applications.

Contents. Chapter 1: Lie Groups and Lie Algebras; Chapter 2: Representation Theory; Chapter 3: Constructive Methods.

September 1989
164 pages / Softcover / ISBN 0-89871-237-8
List Price $24.50 / SIAM Member Price $19.60
Order Code CL02

The Method of Equivalence and Its Applications
Robert B. Gardner

The ideas of Élie Cartan are combined with the tools of Felix Klein and Sophus Lie to present in this book the only detailed treatment of the method of equivalence. An algorithmic description of this method, which finds invariants of geometric objects under infinite dimensional pseudo-groups, is presented for the first time.

As part of the algorithm, Gardner introduces several major new techniques. In particular, the use of Cartan's idea of principal components that appears in his theory of Repere Mobile, and the use of Lie algebras instead of Lie groups, effectively a linear procedure, provide a tremendous simplification.

Method of Equivalence and Applications details ten diverse applications including Lagrangian field theory, control theory, ordinary differential equations, and Riemannian and conformal geometry.

Contents. Equivalence Problems; Lifting of Equivalence Problems to G-Spaces; The Structure Equations; Reduction of the Structure Group by Normalization; The Inductive Step; e-structures; Global Results and Involutive Structure; Serendipity; Normal Forms and Generalized Geometries; Prolongation.

November 1989
124 pages / Softcover / ISBN 0-89871-240-8
List Price $21.75 / SIAM Member Price $17.40
Order Code CB58

To order these books, please contact SIAM.

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☐ 21. Chemical kinetics and combustion theory including thermodynamics and heat transfer.
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☐ 24. Economics.
☐ 25. Social sciences.
☐ 26. Integral and functional equations.
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☐ 28. Math Education((K-12, undergraduate)

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I hereby authorize my telephone number to be listed in the Combined Membership List (CML) of AMS, MAA and SIAM. ☐ Yes ☐ No

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Dues

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SIAM Journal on Control and Optimization (bimonthly)	$42 / $47	_____
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SIAM Journal on Scientific and Statistical Computing (bimonthly)	$42 / $47	_____
Theory of Probability and Its Applications (quarterly)	$95 / $98	_____
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*For journals or SIAM Activity Groups submit 1 x's the 1990 rate. Simply write 18 months next to your signature.

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(Student Members ONLY)

I hereby certify that the applicant is a full-time student or teaching/research assistant, or is a fellow who is actively engaged in a degree program and may be considered to be a full-time student:

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0990

Second International Conference on Industrial and Applied Mathematics

July 8–12 1991

ICIAM 91

Washington D. C.

Local Attractions

Washington D.C. is a world capital and an international city. ICIAM 91 participants will have opportunities during the conference to visit government buildings, museums, and more than 100 well-known historic sites. Travelers to Washington may enjoy the city's stately memorials, the Smithsonian complex of 14 museums and galleries (including the Air and Space Museum), the Capitol Building, and the White House.

These are just a few of the historic sites, 80% of which offer free admission and are open to the public seven days a week.

The Sheraton Washington, host hotel for the conference, has many amenities and is conveniently located on the city's "Metro" subway system.

may also submit an abstract electronically via e-mail. Macros are available in LaTeX or TeX. Ask SIAM via e-mail (*iciam@wharton.upenn.edu*) to send you macros via e-mail. Papers will be reviewed by the program committee. Everyone who submits a paper will be notified by mail regarding acceptance.

To obtain a form and guidelines for submitting a paper, please complete the reply form and return it to SIAM promptly.

Deadline date for submission of contributed presentation forms: September 30, 1990.

ICIAM Update

- More than 1500 applied and computational mathematicians, engineers and scientists worldwide have already sent in requests for abstract and minisymposium proposal forms.
- More than 35% of the requests are from outside the U.S.A.
- More than 60 representatives throughout the world are distributing ICIAM 91 materials.
- Proposals and abstracts already received encompass exciting and recent advances in applied and computational mathematics.

Please send me the following:

- ☐ Abstract form for a contributed presentation—poster or lecture format
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Fill in your name and address below or attach a separate sheet of paper if you need more space.

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CSIC91

Registration Information

Please complete the Advance Registration Form found on the back page of this brochure and return it in the envelope provided in the middle section of this program. We urge attendees to register in advance. Advance registration must be received by October 29, 1990.

Registration fees are listed

REGISTRATION FEE

		SIAG/LA	Member	Non-Member	Student
Short Course	Advance	$115.00	$115.00	$135.00	$75.00
	On-site	$135.00	$135.00	$155.00	$95.00
Conference	Advance	$120.00	$125.00	$160.00	$25.00
	On-site	$145.00	$150.00	$190.00	$25.00

Upcoming Conferences

January 28 - 30, 1991
The Second ACM-SIAM Symposium on Discrete Algorithms (SODA)
Cathedral Hill Hotel
San Francisco, CA

March 25 -27, 1991
Fifth SIAM Conference on Parallel Processing for Scientific Computing
The Westin Galleria Hotel
Houston, TX

May 6 - 8, 1991
Fifth SIAM International Symposium on Domain Decomposition Methods for Partial Differential Equations
Omni Hotel
Norfolk, VA

July 8 - 12, 1991
Second International Conference on Industrial and Applied Mathematics (ICIAM 91)
Sheraton Washington Hotel
Washington, DC

September 16 - 19, 1991
Fourth SIAM Conference on Applied Linear Algebra
Radisson University Hotel
Minneapolis, MN

HOTEL RESERVATION FORM

SIAM CONFERENCE ON LINEAR ALGEBRA

NOVEMBER 5-8, 1990
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Cathedral Hill Hotel, San Francisco, CA

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Conference	Advance	$120.00	$125.00	$160.00	$25.00
	On-Site	$145.00	$150.00	$190.00	$25.00

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Saturday, Nov. 3	6:00 PM - 8:00 PM
Sunday, Nov. 4	8:00 AM - 9:00 PM
Monday, Nov. 5	7:30 AM - 5:00 PM
Tuesday, Nov. 6	7:30 AM - 5:00 PM
Wednesday, Nov. 7	7:30 AM - 5:00 PM
Thursday, Nov. 8	7:30 AM - 3:30 PM

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