Convergence Rate of the Cyclic Reduction Algorithm for Null Recurrent Quasi-Birth-Death Problems

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The minimal nonnegative solution G of the matrix equation $G = A_0 + A_1G + A_2G^2$, where the matrices A_0, A_1 and A_2 are nonnegative and $A_0 + A_1 + A_2$ is stochastic, plays an important role in the study of quasi-birth-death processes (QBDs). The cyclic reduction algorithm is a very efficient iteration for finding the matrix G, under the standard assumption that the transition probability matrix of the QBD and the matrix $A_0 + A_1 + A_2$ are both irreducible. The convergence is known to be quadratic for positive recurrent QBDs and for transient QBDs. For the null recurrent case, the convergence of a closely related algorithm, the Latouche-Ramaswami algorithm, has been shown to be linear with rate 1/2 under two additional assumptions. In this talk, we show that the convergence of the cyclic reduction algorithm and hence of the Latouche-Ramaswami algorithm is at least linear with rate 1/2 in the null recurrent case, without those two additional assumptions, and the proof here is much simpler.

A Structure-Preserving Doubling Algorithm for Quadratic Eigenvalue Problem Arising from Time-Delay Systems

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We propose a structure-preserving doubling algorithm for a quadratic eigenvalue problem arising from the stability analysis of time-delay systems. We are particularly interested in the eigenvalues on the unit circle, which are difficult to estimate. The convergence and backward error of the algorithm are analyzed and three numerical examples are presented. Our experience shows that our algorithm is efficient in comparison to the few existing approaches for small to medium size problem.

A Hyperplane-Constrained Continuation Method for Bound States of Coupled Nonlinear Schrödinger Equations

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Time-independent m-coupled nonlinear Schrödinger equations (NLSEs) that can be used to model nonlinear optics are studied analytically and numerically in this article. Starting from a one-component discrete nonlinear Schrödinger equation (DNLSE), we first propose and analyze an iterative method for finding the ground state solution. This solution is then used as the initial point of the primal stalk solution curve of the m-coupled DNLSEs in a continuation method framework. To overcome the stability and efficiency problems arising in standard continuation methods, we propose a hyperplane-constrained continuation method by adding additional constraints while following the solution curves. Furthermore, we analyze solution and bifurcation properties of the primal stalk solution curve corresponding to the 3-coupled DNLSEs. We also demonstrate computational positive bound states and bifurcation diagrams of the 3-coupled DNLSEs, including non-radially symmetric ground states that are tricky to find in NLSEs.

Dynamics for Discrete-Time Cellular Neural Networks

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This presentation investigates the dynamics of discrete-time cellular neural networks (DT-CNN). In contrast to classical neural networks that are mostly gradient-like systems, DT-CNN possesses both complete stability and chaotic behaviors as different parameters are considered. An energy-like function which decreases along orbits of DT-CNN as well as the existence of a globally attracting set are derived. Complete stability can then be concluded, with further analysis on the sets on which the energy function is constant. The formations of saturated stationary patterns for DT-CNN are shown to be analogous to the ones in continuous-time CNN. Thus, DT-CNN shares similar properties with continuous-time CNN. By confirming the existence of snap-back repellers, hence transversal homoclinic orbits, we also conclude that DT-CNN with certain parameters exhibits chaotic dynamics, according to the theorem by Marotto.

A Structured Doubling Algorithm for Discrete-Time Algebraic Riccati Equations with Singular Control Weighting Matrices

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In this talk we propose a structured doubling algorithm for solving discrete-time algebraic Riccati equations without the invertibility of control weighting matrices. In addition, we prove that the convergence of the SDA algorithm is linear with ratio less than $\frac{1}{2}$ when all unimodular eigenvalues of the closed-loop matrix are semisimple. Numerical examples are shown to illustrate the feasibility and efficiency of the proposed algorithm.

A Test Matrix Generator for Large-Scale Eigenproblem

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Eigentest is a package that produces real test matrices with know eigen-systems. A test matrix, called an eigenmat, is generated in a factored form, in which the user can specify the eigenvalues and has some control over the condition of the eigenvalues and eigenvectors. An eigenmat A of order n requires only $O(n)$ storage for its representation. Auxiliary programs permit the computation of $(A - sI)b$, $(A - sI)^\top b$, $(A-sI)^{-1}b$, and $(A-sI)^{-\top}b$ in $O(n)$ operations. A special routine computes specified eigenvectors of an eigenmat and the condition of its eigenvalue. Thus eigenmats are suitable for testing algorithms based on Krylov sequences, as well as others based on matrix-vector products. This talk introduces the eigenmat and describes implementations in Fortran 77, Fortran 95, C, and Matlab.

A Two-Directional Arnoldi Process and its Application to Parametric Model Order Reduction

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We consider a two-directional Krylov subspace $\mathcal{K}_k(\mathbf{A}_{[j]}, \mathbf{b}_{[j]})$, where besides the dimensionality k of the subspace increases, the matrix $\mathbf{A}_{[j]}$ and vector $\mathbf{b}_{[j]}$ which induce the subspace may also augment. Specifically, we consider the case where the matrix $\mathbf{A}_{[j]}$ and the vector $\mathbf{b}_{[j]}$ are augmented by block triangular bordering. We present a two-directional Arnoldi process to efficiently generate a sequence of orthonormal bases $\mathbf{Q}_k^{[j]}$ of the Krylov subspaces. The concept of a two-directional Krylov subspace and an Arnoldi process is triggered by the need of a multiparameter moment-matching based model order reduction technique for parameterized linear dynamical systems. Numerical examples illustrate computational efficiency and flexibility of the proposed two-directional Arnoldi process.

Numerical Algorithms for Estimating the Largest Structured Singular Value of a μ-Synthesis Control System

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Numerical algorithms for the computation of an upper bound of the largest structured singular value arising from the μ-synthesis control problem are developed. Since the computation for the largest structured singular value has been shown to be an NP-hard problem in literatures, we concentrate the study on the computation for an upper bound of the largest structured singular value. A Newton's type method is proposed. Some theoretical results related to the method are investigated. Numerical implementation shows the efficiency of the method.

A Continuation Method for Positive Bound States of m-Coupled Nonlinear Schrodinger Equations

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We develop a stable continuation method for the computation of positive bound states of time-independent, m-coupled nonlinear algebra equation (DNLS) which describe a m-coupled nonlinear Schrödinger equation. The solution curve with respect to some parameter of the DNLS is then followed by the proposed method. For a one-component DNLS, we develop a iterative method for computation of positive ground state solution. For a m-coupled DNLS, we prove that m radially symmetric positive bound states will bifurcate into m different positive bound states at a finite repulsive inter-component scattering length. Numerical results show that various positive bound states of a three-component DNLS are solved efficiently and reliably by the continuation method.

Structured Quadraticization and Structure-Preserving Algorithm for Palindromic Polynomial Eigenvalue Problems

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

Numerical Computation of Orbits and Rigorous Verification of Existence of Snapback Repellers

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In this talk we show how analysis from numerical computation of orbits can be applied to prove the existence of snapback repellers in discrete dynamical systems. That is, we present a computer-assisted method to prove the existence of a snapback repeller of a specific map. The existence of a snapback repeller of a dynamical system implies that it has chaotic behavior [F. R. Marotto, J. Math. Anal. Appl. **63**, 199 (1978)]. The method is applied to the logistic map and the discrete predator-prey system.

Convergence Analysis of the Doubling Algorithm for Several Nonlinear Matrix Equation in the Critical Case

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In this talk, we review two types of doubling algorithm and some techniques for analyzing them. We then use the techniques to study the doubling algorithm for three different nonlinear matrix equations in the critical case. We show that the convergence of the doubling algorithm is at least linear with rate 1/2. As compared to earlier work on this topic, the results we present here are more general, and the analysis here is much simpler.