Third 1-Day Workshop on Matrix Equations
Braunschweig, 9 October 2009

organized by

Peter Benner (TU Chemnitz)

Heike Faßbender (TU Braunschweig)

Lars Grasedyck (MPI for Mathematics in the Sciences, Leipzig)

Daniel Kressner (ETH Zürich)

Information

Location:

The workshop will take place in the room "Neuer Senatssaal" on the first floor of the "Altgebäude", Pockelsstr. 4, Braunschweig, see

http://www.tu-braunschweig.de/service/besucher/lageplaene

for a map.

Accomodation:

A list of hotels can be found on the webpage

http://www.tu-braunschweig.de/service/besucher/unterkunft

Click on "Sonderkonditionen"/"special conditions" for a list of hotels (German only) with special conditions if you mention "TU Braunschweig" upon reservation.

Further information:

Further information concerning transportation, maps and getting around can be found on the webpage

http://www.tu-braunschweig.de/service/besucher/index.html

Participation fee:

(10 €), to be paid during regsitration.

Workshop dinner:

A joint dinner will take place *preceding* the workshop on October 8, 19:30h, at the *Gewandhaus Restaurant*, Altstadtmarkt 1, 38100 Braunschweig; see

http://www.gewandhaus-bs.de/

for the menu and further information on the restaurant. Participants are on their own.

The Gewandhaus Restaurant is centrally located within walking distance from all hotels in the city center, see

http://maps.google.de/maps?um=1&ie=UTF-8&q=Gewandhaus+Braunschweig

The workshop is endorsed by the **GAMM Activity Group on Applied and Numerical Linear Algebra** and supported by **NICONET e.V.** .

Program Schedule

8:30 - 9:00	Registration
9:00 - 9:10	Opening
9:10 - 9:40	*Beatrice Meini* A unifying framework for several matrix equations
9:45 - 10:15	*Vasile Sima* Advances in structure-preserving algorithms and software for discrete-time algebraic matrix Riccati equations
10:20 - 10:50	Coffee break
10:50 - 11:20	*Timo Reis* Singular optimal control, Lur'e equations and even matrix pencils
11:25 - 11:55	*Safique Ahmad* Perturbation analysis for structured matrix polynomials in the solution of matrix equations
12:00 - 13:30	Lunch break
13:30 - 14:00	*Jens Saak* Recent advances and future challenges in the ADI based numerical solution of large-scale matrix equations
14:05 - 14:35	*Tatjana Stykel* Iterative methods for large-scale projected Lyapunov equations
14:40 - 15:10	Coffee break
15:10 - 15:40	*Elias Jarlebring* A direct method for the H_2 norm of time-delay systems
15:45 - 16:15	*Tobias Damm* Gramians of stochastic and bilinear systems
16:20 - 16:30	Closing Remarks

Abstracts

Perturbation analysis for structured matrix polynomials in the solution of matrix equations

Safique Ahmad

The solution of matrix equations in control leads to eigenvalue problems for structured matrix polynomials. In this work we propose a general framework for the structured perturbation analysis of several classes of structured matrix polynomials in homogeneous form, including complex symmetric, skew-symmetric, even and odd matrix polynomials. We introduce structured backward errors for approximate eigenvalues and eigenvectors and we construct minimal structured perturbations such that an approximate eigenpair is an exact eigenpair of an appropriately perturbed matrix polynomial. This work extends previous work for the non-homogeneous case (we include infinite eigenvalues) and we show that the structured backward errors improve the known unstructured backward errors.

This is joint work with Volker Mehrmann. Research supported by *Deutsche Forschungsgemeinschaft*, via the DFG Research Center MATHEON in Berlin.

Gramians of stochastic and bilinear systems

Tobias Damm

We discuss model order reduction for bilinear systems by balanced truncation and try to give some new interpretation of the truncation error. To this end we consider stochastic inputs are considered. We also address some computational issues.

A direct method for the H_2 norm of time-delay systems

Elias Jarlebring

It is widely known that the solutions of the Lyapunov equations can be used to compute the H_2 norm of LTI dynamical systems. In this talk we show how this theory extends to dynamical system with delays. The first result is that the H_2 norm can be computed from the solution of a generalization of the Lyapunov equation. It turns out that even though a time-delay system is an infinite-dimensional system, this equation can be solved (in exact arithmetic) with elementary linear algebra operations applied to matrices of finite dimension.

This is joint work with J. Vanbiervliet and W. Michiels (K.U. Leuven).

A unifying framework for several matrix equations

Beatrice Meini

We study in a unified fashion several quadratic vector and matrix equations with nonnegativity hypotheses. These equations include a vector equation encountered in Markovian binary trees, nonsymmetric algebraic Riccati equations, their specific instance arising in transport theory, unilateral quadratic matrix equations, and more. Here we treat each of these problems as a specific instance of a general quadratic vector equation. This unifying framework allows to prove general results on the existence of the solutions, and on the convergence of algorithms.

This is joint work with D. A. Bini and F. Poloni.

Singular optimal control, Lur'e equations and even matrix pencils

Timo Reis

Lur'e equations are a generalization of algebraic Riccati equations and they arise in linear-quadratic optimal control problem which are singular in the input. It is well-known that there is a one-to-one correspondence between the solutions of Riccati equations and Lagrangian disconjugate eigenspaces of a certain Hamiltonian matrix. The aim of this talk is to generalize this concept to Lur'e equations. We are led to the consideration of deflating subspaces of even matrix pencils.

Recent advances and future challenges in the ADI based numerical solution of large-scale matrix equations

Jens Saak

The numerical solution of matrix Lyapunov equations has been revealed to be an alternating directions implicit (ADI) model problem decades ago. During the last decade the ADI iteration has been shown to be efficiently applicable especially in the case of large scale sparse or data sparse coefficient matrices. Embedding the ADI iteration in the inner loop of a Newton-Kleinman-iteration, or extending it to the quadratic ADI (QADI), large scale Riccati equations can be solved efficiently. We suggest some modifications to the basic low rank ADI based iterations that can significantly improve the performance of numerical implementations of the algorithm. We will also discuss the challenges of the parallel numerical implementation of these algorithms on modern MultiCore computers.

Advances in structure-preserving algorithms and software for discrete-time algebraic matrix Riccati equations

Vasile Sima

Numerically sound algorithms for discrete-time algebraic matrix Riccati equations are using stable/unstable deflating subspaces for extended, inverse-free symplectic matrix pencils. Recently, there has been a significant theoretical advance in the solution of related palindromic eigenvalue problems, but the associated software is less developed than for the continuous-time counterparts. The talk will investigate the approach based on structure-preserving algorithms and software for the skew-Hamiltonian/ Hamiltonian pencils derived by an extended Cayley transformation, involving only matrix additions and subtractions.

Iterative methods for large-scale projected Lyapunov equations

Tatjana Stykel

We discuss numerical solution of large-scale projected Lyapunov equations. Such equations play a fundamental role in balanced truncation model reduction of descriptor systems. We present generalizations of the alternating direction implicit method, extended Krylov subspace method and global Arnoldi method to the projected Lyapunov equations and compare these methods with respect to their performance on different examples.

Participants

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