E-LETTER of the Numerics in Control Network NICONET
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1 Welcome to the NICONET E-letter number 10!

This E-letter is sent out quarterly and informs you about the newest updates. Also, new NICONET reports and important NICONET activities are announced in this E-letter.

The next issue of this E-letter is planned for July 2001. Please send contributions before June 30. In particular, we encourage contributors to provide information on the use of the SLICOT library (performance, improvements, new suggestions).

Sabine Van Huffel
Chairperson of WGS and Coordinator of NICONET.

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2 New issue of the NICONET Newsletter available

Communicated by Sabine Van Huffel:

The sixth issue of our NICONET Newsletter is now available and can be downloaded as compressed postscript file from the World Wide Web URL:

http://www.win.tue.nl/niconet/ and choose: Newsletters

or from the WGS ftp site:

ftp://wgs.esat.kuleuven.ac.be (directory pub/WGS/NEWSLETTER/)
(filename: issue-1-01.ps.Z)

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3 New additions to SLICOT since November 2000

Communicated by Vasile Sima:

The latest changes in the library contents or routine updates - till the next SLICOT Release - are announced in the file Release.Notes, located in directory /pub/WGS/SLICOT/ on the WGS ftp site. Previous updates are described, in reverse chronological order, in the file Release.History, located in the same directory.

SLICOT routines can be downloaded from the WGS ftp site:

ftp://wgs.esat.kuleuven.ac.be

(directory /pub/WGS/SLICOT/ and its subdirectories) in compressed (gzipped) tar files. On line .html documentation files are also provided there. The library and its documentation are also accessible from the WGS homepage at the World Wide Web URL:

http://www.win.tue.nl/wgs/

after linking from there to the SLICOT web page and clicking on the FTP site link in the freeware SLICOT section.

Over 25 new user-callable and computational routines for basic control problems, for model and controller reduction, and for H-infinity loop shaping have been implemented. They include Analysis Routines, Mathematical Routines, and Synthesis Routines, performing the following main computational tasks:

- computing a reduced order model for an original state-space representation, using the stochastic balancing approach in conjunction with the square-root or the balancing-free square-root Balance & Truncate (B&T) or Singular Perturbation Approximation (SPA) model reduction methods for the alpha-stable part of the system.
- computing a reduced order model for an original state-space representation, using the stochastic balancing approach in conjunction with the square-root or the balancing-free square-root B&T or SPA model reduction methods: state dynamics matrix in real Schur canonical form.
- computing the Cholesky factors of the controllability and observability Grammians.
- computing a reduced order model for an original state-space representation, using the frequency weighted square-root or balancing-free square-root B&T or SPA model reduction methods, trying to minimize the norm of the frequency-weighted error. For unstable systems, only the alpha-stable part is reduced. A specialized routine is available for stable systems with the state dynamics matrix in real Schur canonical form.
- computing the Cholesky factors of the controllability and observability Grammians for systems with input or output weighting transfer-function matrices.
- computing a reduced order model for an original state-space representation, using the frequency weighted optimal Hankel-norm approximation method in conjunction with square-root balancing for the alpha-stable part of the system.
- constructing a state-space representation of the stable projection of a stable, weighted transfer-function matrix, with the state dynamics matrix in real Schur canonical form.
- computing an upper bound on the structured singular value for a given square complex matrix and a given block structure of the uncertainty.
- computing the matrix formula

  $$\bar{R} = alpha*(op(A)'*op(T)'*op(T) + op(T)'*op(T)*op(A)) + beta*R,$$

  or

  $$\bar{R} = alpha*(op(A)'*op(T)'*op(T)*op(A) - op(T)'*op(T)) + beta*R,$$

  where alpha and beta are scalars, R, and $\bar{R}$ are symmetric matrices, T is a triangular matrix, A is a general or Hessenberg matrix, and op(M) = M or op(M) = M'.
- computing the matrix product U'*U or L*L', where U and L are upper and lower triangular matrices, respectively, stored in the corresponding upper or lower triangular part of an array (blocked and unblocked algorithms).
- performing the symmetric rank k operations

  C <- alpha*op(A)*op(A)' + beta*C,

  where alpha and beta are scalars, C is an n-by-n symmetric matrix, op(A) is an n-by-k matrix, and the matrix A has l nonzero codiagonals, either upper or lower.
- computing the matrix product H <- alpha*op(T)*H or H <- alpha*H*op(T), where alpha is a scalar, H is an m-by-n upper or lower Hessenberg-like matrix (with l nonzero subdiagonals or superdiagonals, respectively), and T is a unit, or non-unit, upper or lower triangular matrix.
- computing the Cholesky factor and the generator and/or the Cholesky factor of the inverse of a symmetric positive definite block Toeplitz matrix, defined by either its first block row, or its first block column.

- bringing the first blocks of a generator in proper form.
- applying the transformations created by the SLICOT Library routine MB02CX on other columns or rows of the generator.
- updating the Cholesky factor, the generator, and/or the Cholesky factor of the inverse of a symmetric positive definite block Toeplitz matrix, given the information from a previous factorization and additional blocks of its first block row, or its first block column.
- solving a system of linear equations, T*X = B or X*T = B, with a symmetric positive definite block Toeplitz matrix T, defined either by its first block row or its first block column.
- computing the matrices of the positive feedback controller for the continuous-time shaped plant.
- converting a descriptor state-space system into regular state-space form.
- computing the matrices of the positive feedback controller for the discrete-time shaped plant.
- computing a reduced order controller for an original state-space controller representation, using the frequency weighted square-root or balancing-free square-root B&T or SPA model reduction methods.
- computing the Cholesky factors of the frequency-weighted controllability and observability Grammians corresponding to a frequency-weighted model reduction problem, with the controller state matrix in a block-diagonal real Schur form.
- computing, for a given open-loop model (A,B,C,D), and for a given state feedback gain F and full observer gain G, such that A + B*F and A + G*C are stable, a reduced order controller model (A_c,B_c,C_c,D_c) using a coprime factorization-based controller reduction approach.
- computing, for a given open-loop model (A,B,C,D), and for a given state feedback gain F and full observer gain G, such that A + B*F and A + G*C are stable, a reduced order controller model (A_c,B_c,C_c,D_c) using a coprime factorization-based controller reduction approach. For reduction of the coprime factors, a stability enforcing frequency-weighted model reduction is performed using either the square-root or the balancing-free square-root versions of the B&T model reduction method.
- computing, for a given open-loop model (A,B,C,0), and for a given state feedback gain F and full observer gain G, such that A + B*F and A + G*C are stable, the Cholesky factors S_u and R_u of a controllability Grammian, P = S_u*S_u', and of an observability Grammian, Q = R_u'*R_u, corresponding to a frequency-weighted model reduction of the left or right coprime factors of the state-feedback controller.

In addition, several new mexfiles and Matlab m files have been added in the subdirectories ./SLmex and ./SLTools, respectively. Also, two demonstration packages, for the structured matrix decompositions toolbox, and for the linear systems identification toolbox, have been developed, and can be found in the subdirectory ./SLdemos of the directory Windows.

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4. SLICOT developments

Communicated by Sabine Van Huffel:

A new SLICOT toolbox on structured matrix decompositions is finalized and is available on the website since February 2001.

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5 New NICONET Reports since July 2000

Communicated by Sabine Van Huffel:

The following NICONET reports can be downloaded as compressed postscript files from the World Wide Web URL:

http://www.win.tue.nl/niconet   and choose: reports

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FILE NAME: SLWN2001-1.ps.Z
REPORT NUMBER: 2001-1
FORMAT: Compressed postscript.
AUTHORS: P.Hr. Petkov, D.-W. Gu and M.M. Konstantinov
TITLE: Robust Control of a Triple Inverted Pendulum using mu-Synthesis
ABSTRACT: In this paper we apply some of the SLICOT routines in the mu-synthesis of a robust control system for a triple inverted pendulum. We consider the case of a mixed type uncertainty consisting of two complex uncertainties in the actuators, three real uncertainties in the moments of inertia and three real uncertainties in the viscous friction coefficients.
Using the D-K iteration, a further fictitious complex uncertainty block is included and a mu-controller is constructed for which the closed-loop control system achieves robust stability and robust performance as requested. The influence of the individual uncertainty on the robust stability is investigated using mu-analysis. In addition a reduced order controller is found such that the robust stability and robust performance of the closed-loop system are preserved with the much lower order controller. In the design, the structured singular value mu is calculated with the SLICOT routine AB13MD and the model reduction toolbox in SLICOT is used in the model reduction of the mu controller. The computation experience shows that the SLICOT routines perform better than the counterpart routines in MATLAB in terms of speed and accuracy.
STATUS: available since January 2001

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6 NICONET events

Communicated by Sabine Van Huffel:

Announcement of upcoming SLICOT training course in Bremen, Germany

A first SLICOT tutorial will be held at the University of Bremen, September 27--29, 2001. The title of the training course will be Advanced Computational Tools for Computer-Aided Control Systems Design. It will consist of lectures introducing SLICOT-based software to be used either within Matlab or Scilab. During the training part of the course, the attendees will use this software to solve some practical problems in control systems design. Major topics of the course are basic control software, system identification, model reduction, and robust control design using H-infinity techniques.

Detailed information, program, and registration forms will be mailed to interested persons and will be available in the next issue of the

NICONET Newsletter.

For further information please contact Peter Benner,
email: benner@math.uni-bremen.de.

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7 (Forthcoming) Meetings and symposia attended by NICONET partners

Communicated by Vasile Sima and Sabine Van Huffel:

Conferences related to the NICONET areas of interest, where NICONET partners presented or will present NICONET/SLICOT-related talks and papers, and/or disseminate information and promote SLICOT, are the following:

Tenth SIAM Conference on Parallel Processing, Portsmouth, USA,
March 12--14, 2001.

Fifth SIAM Conference on Control and its Applications, San Diego, USA,
July 11--14, 2001.

SIAM Conference on Linear Algebra in Signals, Systems and Control,
Boston, USA, August 13--16, 2001.

IFAC Workshop on Periodic Control Systems, Cernobbio-Como, Italy,
August 27--28, 2001.

European Control Conference (ECC 2001), Seminario de Vilar, Porto,
Portugal, September 4--7, 2001.

END OF THE NICONET E-LETTER
