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E-LETTER of the Numerics in Control Network NICONET  
Issue no. 4, July 22, 1999

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CONTENTS:

- 1 Welcome to the NICONET E-letter number 4!
  - 2 New issue of the NICONET newsletter available
  - 3 New additions to SLICOT since January 1999
  - 4 New NICONET Reports since April 1999
  - 5 NICONET visits since January 1999
  - 6 NICONET events
  - 7 (Forthcoming) Meetings and symposia attended by NICONET partners
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1 Welcome to the NICONET E-letter number 4!

This E-letter is sent out quarterly and informs you about the newest updates of the SLICOT library, the main product of NICONET, and its performance. Also, new NICONET reports and important NICONET activities are announced in this E-letter. Please, don't forget to attend our next workshop which will be held near Paris, France, in December 1999 (see Section 6).

The next issue of this E-letter is planned for October 1999. Please send contributions before October 10. 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 third 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/wgs/Newslet.html>

or from the WGS ftp site:

<ftp://wgs.esat.kuleuven.ac.be> (directory pub/WGS/NEWSLETTER/  
( filename: issue-2-99.ps.Z)

Contents:

1. Editorial
2. New developments in the SLICOT benchmark library
3. Basic numerical SLICOT tools for control
4. SLICOT tools for model reduction
5. SLICOT tools for subspace identification
6. SLICOT tools for robust control
7. SLICOT tools for nonlinear systems in robotics
8. SLICOT controls microwaves -- a case study
9. SLICOT: a useful tool in industry?
10. Second NICONET workshop in INRIA-Rocquencourt, France
11. NICONET information corner

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3 New additions to SLICOT since January 1999

Communicated by Vasile Sima:

The latest library update took place on June 26, 1999. Known bugs have been corrected out. This resulted in updating over 20 routines. Most changes were needed for setting some output parameters before a Quick return (when some problem dimensions are zero). Details are given in the file Release.Notes, located in root directory pub/WGS/SLICOT/ on the WGS ftp site,

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

which describes the latest changes in the library contents or routine updates (till the next SLICOT Release). Previous updates are described, in reverse chronological order, in the file Release.History, located in the same directory. These files are updated whenever needed.

Several new user-callable routines for basic control problems and model reduction have been made available on the ftp site. They include subroutines from the following library chapters: Analysis Routines, Benchmark and Test Problems, Mathematical Routines, and Synthesis Routines, performing the main tasks listed below:

- model reduction for unstable systems using either the square-root or the balancing-free square-root Balance & Truncate model reduction methods applied to the alpha-stable part of the system;

- model reduction for unstable systems using either the square-root or the balancing-free square-root Singular Perturbation Approximation model reduction methods applied to the alpha-stable part of the system;
- benchmark examples of (generalized) continuous-time or discrete-time Lyapunov equations;
- benchmark examples for standard or generalized time-invariant continuous-time or discrete-time dynamical systems;
- efficient evaluation of various matrix expressions required by other routine calculations;
- computing a solution, optionally corresponding to specified free elements, to a real linear least squares problem;
- solution (if well-conditioned) of the matrix equations  $\text{op}(A)X = B$ , where  $\text{op}(A) = A$  or  $A'$  (the transpose of  $A$ ), providing error bounds on the solution and a condition estimate (this is a simplified version of the LAPACK Library routine DGESVX, useful when several sets of matrix equations with the same coefficient matrix  $A$  and/or  $A'$  should be solved);
- "periodic" Hessenberg reduction: reducing a product of  $p$  real full square matrices,  $H = H_1 H_2 \dots H_p$ , to upper Hessenberg form, where the reduced  $H_1$  is upper Hessenberg, and the reduced  $H_2, \dots, H_p$  are upper triangular, using orthogonal similarity transformations, without evaluating the product;
- computation of the  $p$  real orthogonal matrices performing the "periodic" Hessenberg reduction;
- "periodic" Schur decomposition: finding the factored Schur form and the eigenvalues of a product of matrices,  $H = H_1 H_2 \dots H_p$ , with  $H_1$  an upper Hessenberg matrix and  $H_2, \dots, H_p$  upper triangular matrices, essentially without evaluating the product;
- computing the eigenvalues of a product of matrices,  $T = T_1 T_2 \dots T_p$ , where  $T_1$  is an upper quasi-triangular matrix and  $T_2, \dots, T_p$  are upper triangular matrices;
- pole assignment for a given matrix pair  $(A,B)$  using real Schur form of  $A$ ;
- eigenstructure assignment for a controllable matrix pair  $(A,B)$  in an orthogonal canonical form;
- condition estimate and forward error bound for the solution of a continuous-time or a discrete-time algebraic Riccati equation;
- solving continuous-time or discrete-time algebraic Riccati equations using the enhanced Schur vector method (incorporating scaling and iterative refinement), with condition estimates and forward error bounds;
- condition estimate and forward error bound for the solution of a continuous-time or a discrete-time Lyapunov equation;
- solving continuous-time or discrete-time Lyapunov equations with condition estimates and forward error bounds.

Moreover, several components of the new, SLICOT-based Matlab toolboxes have been posted on the ftp site. At the time being, there are two mexfiles for model reduction, directly callable on Windows 9x or NT platforms (using Fortran 90 memory allocation scheme), and two mexfiles (source form only) for solving standard or generalized Sylvester and Lyapunov equations by various methods, including methods for stable non-negative definite (generalized) Lyapunov equations, which can be used on various platforms (Fortran 77). These mexfiles are invoked by a series of m files, also provided. Included are some Matlab test programs and mat files with test data. The work is in progress, and new mexfiles will be added soon. Performance results and comparisons with Matlab functions will be reported.

In addition, several new user-callable and auxiliary routines for basic and robust control problems have been implemented, and will be made available on the ftp site in the near future.

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.

The whole library is available as the file `slicot.tar.gz`, in the root directory `pub/WGS/SLICOT/`. Several additional files (`.dat`, `.m`, and `.mat`), associated to the newly posted benchmark collections, have been added in the subdirectory `./slicot` of this compressed tar file. Another, similarly organized file, called `slicotPC.tar.gz`, has been put in the same directory `pub/WGS/SLICOT/`; it contains the MS-DOS version of the Fortran source codes of the SLICOT library.

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4 New NICONET Reports since April 1999

Contributed 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/wgs/reports.html>

or from the WGS ftp site:

<ftp://wgs.esat.kuleuven.ac.be> (directory `pub/WGS/REPORTS/`)

FILE NAME: `nic1999-4.ps.Z`  
REPORT NUMBER: `1999-4`  
FORMAT: Compressed postscript.  
AUTHORS: Da-Wei Gu, Petko Hr. Petkov, and Mihail M. Konstantinov  
TITLE: An Introduction to H-infinity Optimisations Designs  
ABSTRACT: This Niconet report is prepared for users of the software package SLICOT who are not familiar with the H-infinity optimisation design approach. Together with some previous Niconet reports it is hoped that the reader would have a general idea about the H-infinity method, know how to use the algorithms available in SLICOT to synthesize a controller for a standard H-infinity optimisation problem and, furthermore, be aware of some difficulties such as singularity in the H-infinity controllers design.  
STATUS: available since May 1999

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FILE NAME: `nic1999-5.ps.Z`  
REPORT NUMBER: `1999-5`  
FORMAT: Compressed postscript.  
AUTHORS: Petko Hr. Petkov, Da-Wei Gu, and Mihail M. Konstantinov  
TITLE: Fortan 77 Routines for H-infinity and H2 Design of Discrete-Time Linear Control Systems  
ABSTRACT: We present Fortran 77 subroutines intended for state-space design of H-infinity (sub)optimal controllers and H2 optimal controllers for linear discrete-time control systems. The subroutines make use of LAPACK and BLAS libraries and produce estimates of the condition numbers of the matrices which are to be inverted and estimates of the condition numbers of the matrix algebraic Riccati equations which are to be solved in the computation of the controllers. The subroutines will be included in the SLICOT library.  
STATUS: available since May 1999

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FILE NAME: SLWN1999-6.ps.Z  
REPORT NUMBER: 1999-6  
FORMAT: Compressed postscript.  
AUTHORS: Daniel Kressner, Volker Mehrmann, Thilo Penzl  
TITLE: CTLEX - a Collection of Benchmark Examples for Continuous-Time Lyapunov Equations  
ABSTRACT: This paper describes the benchmark collection CTLEX, that contains test examples of continuous-time algebraic Lyapunov equations. The main focus of this collection is on scalable benchmark examples depending on parameters, which affect the conditioning of the equation. Such examples are particularly useful for the assessment of the complexity and the accuracy of numerical solution methods.  
STATUS: available since June 1999

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FILE NAME: SLWN1999-7.ps.Z  
REPORT NUMBER: 1999-7  
FORMAT: Compressed postscript.  
AUTHORS: Daniel Kressner, Volker Mehrmann, Thilo Penzl  
TITLE: DTLEX - a Collection of Benchmark Examples for Discrete-Time Lyapunov Equations  
ABSTRACT: This paper describes the benchmark collection DTLEX, that contains test examples of discrete-time algebraic Lyapunov equations. These matrix equations are also known as Stein equations. The main focus of DTLEX is on scalable benchmark examples depending on parameters, which affect the conditioning of the equation. Such examples are particularly useful for the assessment of the complexity and the accuracy of numerical solution methods.  
STATUS: available since June 1999

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FILE NAME: nic1999-8.ps.Z  
REPORT NUMBER: 1999-8  
FORMAT: Compressed postscript.  
AUTHORS: Andras Varga  
TITLE: Model Reduction Routines for SLICOT  
ABSTRACT: We report on the newest developments of model reduction software for SLICOT. Three enhanced accuracy model reduction algorithms belonging to the class of methods based on or related to balancing techniques form the basis of model reduction software in SLICOT. These methods are primarily intended for the reduction of linear, stable, continuous- or discrete-time systems. However, in combination with additive spectral decomposition or coprime factorization techniques the basic methods can be employed to reduce unstable systems too. The implemented computational methods for reduction of stable and unstable systems, and the associated software available in SLICOT are presented. Performance comparisons performed using appropriate interface software to user-friendly environments like MATLAB and Scilab show the superiority of SLICOT model reduction tools over existing model reduction software.  
STATUS: available since June 1999

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FILE NAME: SLWN1999-9.ps.Z  
REPORT NUMBER: 1999-9  
FORMAT: Compressed postscript.  
AUTHORS: Paul Van Dooren  
TITLE: Selection of basic software tools for structured matrix decompositions and perturbations  
ABSTRACT: In this note a survey is given of areas of systems and control where structured matrix problems are important. In identification we mention four different types of data

collection : impulse response, input-output pairs, frequency response and covariance data. In each of those, the identification problem can be rewritten in terms of structured matrix problems for which there exist fast decompositions. The use of structured matrix decompositions should yield an improvement in speed of computations. In analysis and design one encounters eigenvalue problems with specific structure such as cyclic, Hamiltonian and symplectic matrices. For those problems it is important to use structure preserving decompositions, mainly to improve the numerical accuracy of the computations, although these algorithms typically yield improved computational complexities as well. We also list the key numerical routines that should be provided in the SLICOT library in order to tackle most of the problems mentioned in this note.

STATUS:

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#### 5 NICONET visits since January 1999

February 24--27, 1999: Hongguo Xu from the Technical University of Chemnitz visited Peter Benner and Heike Fassbender at the University of Bremen to discuss issues related to the SLICOT-based Matlab Toolbox for Basic Control Tools.

March 14--17, 1999: Peter Benner from the University of Bremen visited Vicente Hernandez at the Politechnic University of Valencia in order to discuss issues related to the development of a parallel extension of SLICOT.

June 14--June 18, 1999: A. Varga visited INRIA in order to include the new model reduction tools developed into Scilab via user-friendly interfaces.

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#### 6 NICONET events

Communicated by Sabine Van Huffel:

May 31--June 1, 1999. Fourth two-days NICONET meeting organized at Delft University of Technology, the Netherlands, and attended by all partners.

Our second NICONET workshop will be held at INRIA Rocquencourt in France on December 3, 1999. This workshop is open for everybody and is announced below:

#### Second NICONET WORKSHOP:

NUMERICAL CONTROL SOFTWARE: a useful tool in industry

Friday, December 3, 1999, INRIA Rocquencourt, France

#### First Announcement and Call for Posters

This workshop organized by the European Numerics in Control thematic Network (NICONET) aims to bring together engineers, mathematicians, computer scientists and practitioners from industry and academia dealing with numerical software in systems and control and their implementation and use in industrial practice.

Recent advances on the use of numerical software libraries especially

designed for solving systems and control engineering problems in a numerically reliable and efficient way will be discussed. The current status of the freely available SLICOT library will be extensively discussed, as well as industrial control applications and future extensions, comprising parallel versions and practically oriented benchmarks. SLICOT is a valuable tool for the reliable solution of many control problems, and for large-scale, computer-intensive control problems and real-time applications, SLICOT can lead to significant performance improvements.

Chairpersons: Francois Delebecque, Serge Steer (local organizers) and Sabine Van Huffel (project coordinator).

Organizing Committee: T. Backx, P. Benner, A. van den Boom, J. De Cuyper, A. Coville, D.W. Gu, S. Hammarling, V. Hernandez, B. Kagstrom, M. Konstantinov, V. Mehrmann, A. Moner, P. Petkov, V. Sima, A. Stoorvogel, P. Van Dooren, A. Varga, M. Verhaegen, R. Wohlgemuth.

#### Workshop Program:

The morning session consists of a tutorial training course including demos of the newly developed SLICOT toolboxes which enable the use of SLICOT routines within the user-friendly CACSD packages MATLAB and Scilab. In the afternoon, plenary talks are scheduled describing the use of numerical control software in diverse industrial control applications. In addition, a poster session of contributed papers illustrates new developments in control software and their performance in engineering practice and industrial applications.

- 9h-10h: 'The numerics in control library SLICOT: an introductory presentation' by Dr. Ad van den Boom (Eindhoven University of Technology) and Prof. Sabine Van Huffel (Katholieke Universiteit Leuven)
- 10h30-12h30: Introductory presentations of the newly developed SLICOT toolboxes including demos
- 'Basic software tools' by Prof. Paul Van Dooren (Universite Catholique de Louvain)
  - 'Model reduction' presented by Dr. Andras Varga (DLR, Oberpfaffenhofen)
  - 'Subspace identification' by Prof. Michel Verhaegen (Delft University of Technology)
  - 'Robust control' presented by Dr. Dawei Gu (University of Leicester)
- 14h-16h: Plenary session (tentative schedule)  
Presentation of Scilab through a large industrial application by Eric Demay from Electricite de France.
- Industrial control applications of SLICOT presented by the NICONET industrial partners:  
Ir. Joris De Cuyper from LMS International, Leuven, Belgium.  
Ir. Arnaud Coville from SFIM Industries, Massy, France.  
Dr. ir. Jobert Ludlage from IPCOS, Boxtel, the Netherlands.
- 16h-17h30: Demos and poster session
- 17h30-18h: Closing discussion
- 18h: Reception

The preliminary, as well as the final program, will be announced on the NICONET website <http://www.win.tue.nl/wgs/niconet.html>

Participants of the workshop receive:

- A copy of the workshop program and proceedings book
- A copy of the last version of the SLICOT Software Library and Toolboxes (upon request)
- Documentation on SLICOT and NICONET

Prospective authors are invited to submit two copies of a camera-ready

paper (1 to 5 pages long), describing the contents of the poster contribution, to the workshop secretariat (see address below) for review. Address and e-mail should be provided if possible. All accepted contributions, as well as documentation for the tutorial training course and the plenary session, will be published in the workshop proceedings.

Author's Schedule:

Submission of camera-ready paper (1-5 pages): November 10, 1999.  
Notification of acceptance as poster presentation: November 15, 1999.

Registration Information:

Please register your attendance to the workshop at the address below before November 15, 1999.

The attendance to the workshop, the documentation and the software are free.

Second NICONET workshop Registration Form, Friday December 3, 1999.

Name:  
Title:  
Company/Institution:  
Area:  
Address:  
Phone:  
Fax:  
e-mail:

To the attention of Mrs Christine Bren at the workshop secretariat

By Fax: + 33-1-39635638

By Mail: INRIA, Relations Exterieures  
Domaine de Voluceau Rocquencourt B.P. 105  
78153 Le CHESNAY CEDEX (France)

By WWW: <http://www-rocq.inria.fr/Niconet/register.html>

By e-mail: [symposia@inria.fr](mailto:symposia@inria.fr)

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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:

June 14--June 18, 1999. S. VAN HUFFEL, V. MEHRMANN, S. HAMMARLING, P. BENNER, A. VARGA, P. VAN DOOREN, AND BO KAGSTROM attended the 14th Householder symposium on Numerical Linear Algebra, Whistler B.C., Canada, and presented the following talk:  
SLICOT -- A Subroutine Library in Systems and Control Theory.

The Fourth International Congress on Industrial and Applied Mathematics, Edinburgh, Scotland, ICIAM99, July 5-9, 1999.

19th IFIP TC7 Conference on System Modelling and Optimization, Cambridge, England, July 12--16, 1999.

1999 IEEE International Symposium on Computer-Aided Control System Design, CACSD '99, Hawaii, August 22--26, 1999.

European Control Conference, Karlsruhe, Germany, 31 August --  
3 September, 1999.

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END OF THE NICONET E-LETTER  
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