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NICONET Newsletter

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1 Editorial

Welcome to the tenth issue of the NICONET newsletter which informs you about the evolution of the SLICOT library and its integration in user-friendly environments such as `Scilab` and MATLAB, as well as about other NICONET activities related to CACSD software developments. Since July 1, 2002, our EC thematic network project came to its end. However, the maintenance and further development of the SLICOT library will be guaranteed by our international society, also called NICONET, which is operational since September 2001. Any funding received through this society will be used for the further development of the SLICOT library, as well as for the promotion and dissemination of the SLICOT software.
Section 2 presents the special session organized by members of the NICONET team at *The IEEE International Symposium on Computer-Aided Control System Design, CACSD 2002*, Glasgow, Scotland, 18–20 September 2002. Finally, Section 3 gives more details about the newest additions to the SLICOT library, new reports and forthcoming events.

I hope you enjoy reading this newsletter.

Sabine Van Huffel
NICONET coordinator

2 The IEEE International Symposium on Computer-Aided Control System Design, Glasgow, Scotland, 18–20 September 2002

During 18–20 September 2002, *The IEEE International Symposium on Computer-Aided Control System Design, CACSD 2002* was held in Glasgow, Scotland, in conjunction with the *2002 IEEE International Conference on Control Applications, CCA 2002*. The conferences were well organized and well attended. Several interesting plenary lectures, e.g., "Opportunities in Automotive Powertrain Control Applications" (J. Cook), "System Science: The Convergence of Communication, Computation and Control" (S. Mitter), "Smart Control for Tomorrows Processes" (R. Benson), etc., have been presented. Tutorial Workshops were organized on September 17. The Proceedings on CD-ROM were made available to the conference participants. Publishers and software companies, including John Wiley and Sons Ltd., Springer Verlag London, National Instruments, and The MathWorks, presented their latest products.

Besides the technical program, the very well organized Social Events included Welcome Reception, Civic Reception (at Glasgow City Chambers), Conference Banquet, and Farewell Reception.

The CACSD 2002 symposium included an invited special session (Session **WM 7**), entitled *Advances in CACSD numerical software and applications*, hosted by NICONET members. The session was organized by Dr. Vasile Sima and Dr. Da-Wei Gu and was chaired by V. Sima and Dr. Andras Varga. It took place on the first conference day, Wednesday morning, from 10 to 12 a.m., and was well attended. A short description of the session follows (adapted from the submitted session proposal).

> The complexity of challenging problems in computer-aided control systems analysis and design (CACSD), as well as in practical control applications, requires very efficient and reliable algorithms and associated software. Typical control problems are often ill-posed or ill-conditioned, badly scaled, and/or have high dimension. Consequently, standard CACSD software packages often fail and/or are too inefficient.
>
> This invited session presents recent achievements obtained in basic system and control tools, model and controller reduction, system identification, robust control analysis and design, and nonlinear systems simulation. New or improved algorithms have been developed and implemented in the freely-available library SLICOT—Subroutine Library in Control Theory. Efficiency and reliability are achieved by exploiting problem-structure, by using condition estimators, and powerful linear algebra tools. SLICOT routines are based on advanced theoretical algorithms and state-of-the-art numerical packages LAPACK (Linear Algebra Package) and BLAS (Basic Linear Algebra Subprograms), as well as their extensions for parallel computer architectures. The SLICOT-related software integrates MATLAB and Scilab interfaces, benchmark examples, and demonstration packages. Some relevant results and case studies have been illustrated during this invited session. The numerical experience and comparisons with available toolboxes show that SLICOT routines provide accurate results and more details on problem conditioning. Moreover, for some applications, SLICOT-based calculations are by over one or two orders of magnitude faster than calculations performed using other standard tools (even on serial machines, and without optimized BLAS).

The following talks were given:

1. S. Van Huffel and V. Sima, *SLICOT and control systems numerical software packages*, presented by V. Sima.

2. V. Sima, D.M. Sima, and S. Van Huffel, *SLICOT system identification software and applications*, presented by D.M. Sima.

3. A. Varga, *Numerical software in SLICOT for low order controller design.*

4. P.Hr. Petkov, D.-W. Gu and M.M. Konstantinov, *Robust μ-design of a disk drive servo system*, presented by D.-W. Gu.

5. J. De Cuyper, D. Vaes, W. Dehandschutter, J. Swevers, M. Verhaegen, and P. Sas, *Experimental $\mathcal{H}_\infty$ control to improve an industrial off-line tracking control scheme on an automotive suspension test rig*, presented by J. De Cuyper.

6. V. Sima, *SLICOT Demonstration.*

There have been some discussions related to some talks during the session, but also after it. The demonstration talk presented the basic control solvers, and system identification for linear and Wiener systems. Difficult problems have been solved lively, to illustrate the SLICOT capabilities. The first five presentations are included in the conference proceedings.

It has been concluded that the SLICOT session was a very successful event.

Vasile Sima

3 NICONET information corner

This section informs the reader on how to access the SLICOT library, the main product of the NICONET project, and how to retrieve its routines and documentation. Recent updates of the library are also described. In addition, information is provided on the newest NICONET reports, available via the NICONET website or ftp site, as well as information about upcoming workshops/conferences organized by NICONET or with a strong NICONET representation.

Additional information about the NICONET Thematic Network can be found from the NICONET homepage World Wide Web URL

`http://www.win.tue.nl/wgs/niconet.html`

3.1 Electronic Access to the Library

The 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. It is possible to browse through the documentation on 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 SLICOT index is operational there. Each functional "module" can be copied to the user's current directory, by clicking on an appropriate location in the `.html` image. A "module" is a compressed (gzipped) tar file, which includes the following files: source code for the main routine and its example program, example data, execution results, the associated `.html` file, as well as the source code for the called SLICOT routines.

The entire library is contained in a file, called `slicot.tar.gz`, in the SLICOT root directory `/pub/WGS/SLICOT/`. The following Unix commands should be used for decompressing this file:

```
gzip -d slicot.tar
tar xvf slicot.tar
```

The created subdirectories and their contents are summarized below:

`slicot`	contains the files `libindex.html`, `make.inc`, `makefile`, and the following subdirectories:
`benchmark_data`	contains benchmark data files for Fortran benchmark routines (`.dat`);
`doc`	contains SLICOT documentation files for routines (`.html`);
`examples`	contains SLICOT example programs, data, and results (`.f`, `.dat`, `.res`), and `makefile`, for compiling, linking and executing these programs;
`examples77`	the same contents as in subdirectory `examples`, but the programs are compliant with the Fortran 77 standard (with the `MAX` and/or `MIN` intrinsic functions calls in `PARAMETER` statements removed);

`src`	contains SLICOT source files for routines (`.f`), and `makefile`, for compiling all routines and creating an object library;
`SLTools`	contains MATLAB `.m` files and data `.mat` files;
`SLmex`	contains Fortran source codes for MEX-files (`.f`).

Another, similarly organized file, called `slicotPC.zip`, is available in the SLICOT root directory; it contains the MS-DOS version of the source codes of the SLICOT Library, and can be used on Windows 9x/2000/ME or NT platforms. Included are several source makefiles.

After downloading and decompressing the appropriate SLICOT archive, the user can then browse through the documentation on his local machine, starting from the index file `libindex.html` from `slicot` subdirectory.

3.2 SLICOT Library updates in the period July 2002–January 2003

There has been one major SLICOT Library update during the period July 2002–January 2003: on October 1. Details are given in the file `Release.Notes`, located in the root directory, `pub/WGS/SLICOT/`, of the SLICOT ftp site.

The *SLICOT Library update on October 1, 2002*, included changes in several routines and associated interfaces. The updated Fortran routines are: `MB02CU`, `MB02HD`, `MB02ID`, `MB02JD`, and `MB02JX`, related to computations with structured matrices. Some bugs found while performing detailed testing using the newly developed MEX-file `fstoeq` were fixed. The updates mainly consisted in defining more restrictive conditions for performing some calculations, usually made by calling various BLAS routines. The length of the workspace has been slightly increased for `MB02JX`. Details are given in the file `Release.Notes`.

The `html` documentation has also been updated for `MB02HD`, `MB02JD`, and `MB02JX` (according to the functional changes made), and in `SG02AD` (added comments related to the solution of the associated optimal control problem when matrix R is singular). A document for `SB10ZD` has been added. Moreover, on-line `html` documentation files for SLICOT routines performing model reduction on parallel computers, using either direct or iterative methods, have been made available on the SLICOT ftp site.

Severeal M-files (`Contents`, `pass`, `persch`, and `polass`—the help part), and the MEX-files `perschur` and `polass` have been updated. A new MEX-file, called `fstoeq`, has been added; it computes an orthogonal-triangular/trapezoidal decomposition (with partial column pivoting) of a (banded) block Toeplitz matrix.

Executable MATLAB 6.1 MEX-files have been generated for Sun Sparc-Solaris. They are stored in the compressed file `mexsolfiles6.tar.gz`, subdirectory `MatlabTools/Unix/SLTools` of the SLICOT ftp site. The MEX-files `fstoeq`, `perschur` and `polass` are not currently included. The available MEX-files have been tested on a Sun sparc SUNW Ultra-2 (machine hardware sun4u, OS version 5.8).

Several new M-files, mainly for computations with structured matrices (`btoeplitz2`, `fstlsq`, `fstmul`, and `fstqr`) have been added, together with the associated test script file, `test_fstoeq`. Two additional test scripts for pole assignment and periodic Hessenberg and/or Schur decomposition of a matrix product (`test_pass` and `test_persch`, respectively) have been included.

A new demonstration file, `widentdemo.zip`, for Wiener systems identification has been designed and made available from the SLICOT ftp site or NICONET Web site. Moreover, all previously available MATLAB 5.3 demonstration files have been moved in a subdirectory called

SLdemos5, and new versions for MATLAB 6.1 replaced the existing files in the subdirectory SLdemos.

Finally, a new directory, called prebuilt, now contains prebuilt SLICOT object library files. The following files are currently included:

slicot_solaris77.tar.gz :	containing slicot.a, the object library file for Sun sparc Ultra-2 machines, built using Sun WorkShop Compiler FORTRAN 77 5.0.
slicot_solaris90.tar.gz :	containing slicot.a, the object library file for Sun sparc Ultra-2 machines, built using Sun WorkShop Compiler FORTRAN 90 2.0.
slicot_win32.zip :	containing slicot.lib, the object library file for PC Windows 9x/NT/ME/2000 machines, built using Compaq Visual Fortran 6.5.
slicot_linux77.tar.gz :	containing slicot.a, the object library file for Red Hat Linux 7.2 machines, built using Fortran 77.

The html files describing various NICONET tasks have been updated on the NICONET Web page. Also, several readme files from the SLICOT ftp site have been changed, and new files added when needed.

Changes performed since October 1, 2002, which will be incorporated in the next SLICOT Library update, include:

- Some bugs have been fixed in the routine MB03SD: the values JOBSCL = 'P' and 'B', for which the Hessenberg form of the matrix A'' would not be preserved, have been removed; the lower triangle below the Hessenberg form was annihilated when JOBSCL = 'S', and the efficiency was improved by using BLAS 3 calls to DSYMM as much as possible.

- A workspace pointer has been redefined before the second call of SB02SD in SB10SD.

- A new MEX-file (Hamileig) and associated M-files (Hameig and test_Hameig), which compute the eigenvalues of a Hamiltonian matrix using the square-reduced approach, have been written. Moreover, new help functions for the MEX-files bstred, conred, fwehna, fwered, and sfored have been prepared. The file Contents.m has been updated.

- Several zip-files (e.g., conred_mex.zip, hinf_mex.zip, dllfiles.zip, dllfiles6.zip, etc.) have been updated. The test files in the archive conred_mex.zip were made fully operational also under MATLAB 5.3. Also, the files mfiles.zip and mfiles.tar.gz, as well as mexfiles.zip and mexfiles.tar.gz have been extended to include the new M-files and MEX-files, respectively.

- An additional Web page file, which enables the interested users to easily dowload additional SLICOT-related software, such as prebuilt object-code libraries for several common computer platforms, or related, contributed Fortran routines or MATLAB functions, not yet included in the SLICOT Library, was added on the NICONET Web page.

- Several M-files written by prof. Andre L. Tits and his collaborators (Craig T. Lawrence, and Yaguang Yang), including the μ-norm computation files (munorm, test_scalar, test_mixed, and test_complex) and robust pole assignment files (robpole, complex_pair,

real_pair, and one_column), have been analyzed, some bugs were found and communicated to the authors, and then removed. Also, some improvements have been proposed and operated. These files are to be added in the subdirectory MatlabTools/contrib.

- Several routines for solving algebraic Riccati equations (SB02MD, SB02OD, SB02OY, SB02RD, and SG02AD), as well as the related M- and MEX-files have been improved. Specifically, internal scaling has been incorporated in SB02OD, to increase accuracy and reliability for poorly scaled equations; moreover, a standard eigenproblem is solved for continuous-time equations when the matrix G is given. In addition, the natural tendency of the QZ algorithm to get the largest eigenvalues in the leading part of the matrix pencil is exploited for discrete-time Riccati equations, by computing the unstable eigenvalues of the permuted matrix pencil. This last improvement has been also performed in SG02AD. The second matrix is not built (and memory is saved) for continuous-time problems with G given and identity matrix E, in SB02OY, since a standard eigenproblem is solved in this case. Finally, the scaling factor used is now returned in SB02MD and SB02RD.

  The improvements made in the Riccati solvers generated some changes in the associated MEX-files (aresol, aresolc) and M-files (slcares, sldares, slcaresc, sldaresc, test_aresol, test_aresolc).

- All SLICOT test functions for SLICOT MEX-files and M-files have been run under MATLAB 6.5. This required to change several funtions for model and controller reduction, to avoid interpreting the local variable discr as a logical array. The changed functions are bst, bta, btabal, btabal_cf, bta_cf, cfconred, fwbconred, fwbred, fwhna, hna, lcf, lcfid, rcf, rcfid, spa, spabal, spabal_cf, spa_cf, and test_conred. These changed functions have been successfully re-checked under MATLAB 5.3 and 6.1.

3.3 New NICONET Reports

Recent NICONET reports (available after July 2002), that 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/), are the following:

- Andras Varga. *New Numerical Software for Model and Controller Reduction* (file SLWN2002-5.ps.Z, August 2002).

  We describe the recently developed model and controller reduction software for SLICOT within Task II.B of the NICONET Project. A powerful collection of user callable Fortran 77 routines has been implemented based on the latest algorithmic developments which cover the relative error model reduction using the balanced stochastic truncation approach, model reduction using frequency-weighted balancing and frequency-weighted Hankel-norm approximation methods, as well as special controller reduction methods using the frequency-weighted balancing and coprime factorization based techniques. All implemented routines can be employed to reduce both stable and unstable, continuous-

or discrete-time models or controllers. The underlying numerical algorithms are based on extensions of the square-root and balancing-free accuracy enhancing technique developed by the author for balancing-related model reduction. The new model and controller reduction routines for SLICOT are among the most powerful and numerically most reliable software tools available for model and controller reduction. To facilitate their usage, easy-to-use and flexible interfaces have been developed to integrate them in MATLAB and Scilab.

- Peter Benner, Enrique S. Quintana-Orti and Gregorio Quintana-Orti. *Experimental Evaluation of the Parallel Model Reduction Routines in PSLICOT* (file `SLWN2002-7.ps.Z`, August 2002).

  An experimental evaluation is reported, including numerical aspects and parallel performance, of the parallel routines for absolute error model reduction in PSLICOT based on iterative solution of the underlying matrix (Lyapunov) equations. The frequency response and the performance of the parallel routines are compared with those of the analogous codes in SLICOT.

- Da Wei Gu, Mihail M. Konstantinov, Volker Mehrmann, Petko Petkov, Hongguo Xu. *DRCEXC – A Collection of Benchmark Examples for Robust Control Design of Continuous-Time Dynamical Systems Version 1.0* (file `SLWN2002-8.ps.Z`, November 2002).

  In this report we present a collection of benchmark example problems for robust control design of linear continuous-time systems. The collection is intended to be used with the SLICOT library of routines for $\mathcal{H}_\infty$ and μ-design of robust control systems. The present version of the collection includes nine systems. The benchmark examples are implemented in MATLAB M-files.

Previous NICONET/WGS reports are also posted at the same address.

3.4 Forthcoming Conferences

Forthcoming Conferences related to the NICONET areas of interest, where NICONET partners submitted proposals for NICONET/SLICOT-related talks and papers, and will disseminate information and promote SLICOT, include the following:

- The 11th Mediterranean Conference on Control and Automation MED'03, June 17-20 2003, Rhodes, Greece.
- The 8th SIAM conference on Applied Linear Algebra, The College of William and Mary, Williamsburg, VA, U.S.A., July 16-19, 2003.
- The 13th IFAC Symposium on System Identification, SYSID 2003, August 27-29, 2003, Rotterdam, The Netherlands.
- The 7th European Control Conference ECC03, Sept. 1–4, 2003, University of Cambridge, UK.

Vasile Sima