# Selected Topics in Numerical Linear Algebra and Control

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This course is concerned with numerical issues of algorithms for signals, systems and control. In doing so, we will mainly focus on linear time-invariant (LTI), finite-dimensional systems. The importance of such systems stems from the following facts: they are mathematically well understood, they can be treated by reliable numerical algorithms, and many physical processes can be discretized/linearized into LTI systems. The aim of this course is to provide an overview of state-of-the-art techniques for some of the most frequently encountered tasks in control theory. Particular attention will be paid to the intimate relationship between numerical linear algebra and control theory, which helps design very efficient and reliable methods to solve these tasks. Pointers to popular software for designing and analyzing LTI systems, such as SLICOT and the MATLAB Control Toolbox, will be provided.

No preliminary knowledge of control theory is assumed. Familiarity with common concepts and algorithms from numerical linear algebra and/or access to [3] is helpful. The course is intended to cover the following topics:

**System Analysis** – solvability, stability, controllability, observability, condensed and canonical forms, distance concepts, Laplace transform, system norms, Bode plot;

**System Identification** – state space realization, frequency domain identification, subspace identification, POD;

**Model Reduction** balanced truncation, linear matrix equations, Krylov subspace methods;

**State Space Design:** pole placement, optimal control, Riccati equations, $H_\infty$ control.

## Related References

[1] P. Benner, V. Mehrmann, V. Sima, S. Van Huffel, and A. Varga. SLICOT—a subroutine library in systems and control theory. Available from `http://www.win.tue.nl/niconet/`.

[2] G. H. Golub and P. Van Dooren (editors). *Numerical Linear Algebra, Digital Signal Processing and Parallel Algorithms*. Proceedings of the NATO Advanced Study Institute held in Leuven, August 1–12, 1988. Springer-Verlag, Berlin, 1991.

[3] G. H. Golub and C. F. Van Loan. *Matrix Computations*. Johns Hopkins University Press, Baltimore, MD, third edition, 1996.

[4] P. H. Petkov, N. D. Christov, and M. M. Konstantinov. *Computational Methods for Linear Control Systems*. Prentice-Hall, Hertfordshire, UK, 1991.

[5] V. Sima. *Algorithms for Linear-Quadratic Optimization*, volume 200 of *Pure and Applied Mathematics*. Marcel Dekker, Inc., New York, NY, 1996.

[6] P. Van Dooren. *Numerical Linear Algebra for Signal, Systems and Control*. Draft notes prepared for the Graduate School in Systems and Control, 2003. Available from `http://www.inma.ucl.ac.be/~vdooren/grad.html`.

[7] K. Zhou, J. C. Doyle, and K. Glover. *Robust and Optimal Control*. Prentice-Hall, Upper Saddle River, NJ, 1996.

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