Numerical Linear Algebra Seminar

Matrix Functions: Theory, Computation and Applications

Winter Semester 2015/16

Prof. Jörg Liesen (11.10.2015)

First meeting:
Wednesday, 14.10.15 (first week of classes), 16:00-18:00, ???

> Matrix functions are of growing interest due to their fascinating theory and the many applications in which they provide insight and succinct solutions.
> (Nicholas J. Higham, *Functions of Matrices*, SIAM, Philadelphia, 2008)

The seminar will deal with recent developments in the theory, computation and applications of matrix functions. As indicated by the above quote, the study of matrix functions is currently one of the most active areas of research in numerical linear algebra. For a brief survey see

> N. J. Higham and L. Lin, Matrix Functions: A Short Course
> `http://eprints.ma.man.ac.uk/2067/01/covered/MIMS_ep2013_73.pdf`

In the first meeting of the seminar I will give a brief introduction into the theory of matrix functions and illustrate their use in network analysis. In all further meetings, which will be scheduled in (few) blocks towards the end of the semester (late January and/or early February), students will individually present the content of research papers. All topics are suitable for a writing BA thesis following the seminar, which may use the written report (see below) as a starting point. Topics for MA theses, which naturally are more comprehensive, can be discussed on an individual basis.

Participation in the seminar requires (1) giving a talk on a research paper and (2) writing a report ("Ausarbeitung") on the paper (details to be announced). Some of the papers are quite long and will probably be split and assigned to more than one student. The final grade (if required) will be based in equal parts on the talk and the written report.

Interested students should select **at least three** of the papers listed on the next page and send me an email (liesen@math.tu-berlin.de) with the titles **until October 11, 2015**. Please also indicate whether you are interested in writing a BA or MA thesis following the seminar. I will distribute topics (one per student) during the first meeting based on the selections I have received by email.

1. M. Aprahamian and N. J. Higham, The Matrix Unwinding Function, with an Application to Computing the Matrix Exponential, SIAM J. Matrix Anal. Appl., 35 (2014), pp. 88-109.
http://eprints.ma.man.ac.uk/2094/01/covered/MIMS_ep2013_21.pdf
2. R. Byers and H. Xu, A New Scaling for Newton's Iteration for the Polar Decomposition and its Backward Stability, SIAM. J. Matrix Anal. Appl., 30 (2008), pp. 822-843.
https://www.math.ku.edu/~xu/arch/bx1-07R2.pdf
3. M. Benzi and G. H. Golub, Bounds for the Entries of Matrix Functions with Applications to Preconditioning, BIT, 39 (1999), pp. 417-438.
http://www.mathcs.emory.edu/~benzi/Web_papers/BITBenziGolub.pdf
4. M. Benzi, E. Estrada and C. Klymko, Ranking Hubs and Authorities Using Matrix Functions, Linear Algebra Appl., 438 (2013), pp. 2447-2474.
http://www.mathcs.emory.edu/~benzi/Web_papers/bek_13.pdf
5. M. Benzi and C. Klymko, Total Communicability as a Centrality Measure, Journal of Complex Networks, 1 (2013), pp. 124-149.
http://www.mathcs.emory.edu/~benzi/Web_papers/cnt007.pdf
6. M. Benzi and N. Razouk, Decay Bounds and $O(N)$ Algorithms for Approximating Functions of Sparse Matrices, ETNA, 28 (2007), pp. 16-39.
http://www.mathcs.emory.edu/~benzi/Web_papers/benzi_razouk.pdf
7. V. Druskin and L. Knizhnerman, Extended Krylov Subspaces: Approximation of the Matrix Square Root and Related Functions, SIAM. J. Matrix Anal. Appl., 19 (1998), pp. 755-771.
http://epubs.siam.org/doi/abs/10.1137/S0895479895292400
8. M. Eiermann and O. G. Ernst, A Restarted Krylov Subspace Method for the Evaluation of Matrix Functions, SIAM J. Numer. Anal., 44 (2006), 2481-2504.
https://www.tu-chemnitz.de/mathematik/numa/PubArchive/eiermannErnstKrylovExp.pdf
9. M. Fasi, N. J. Higham and B. Iannazzo, An Algorithm for the Matrix Lambert W Function, SIAM J. Matrix Anal. Appl., 36 (2015), pp. 669-685, 2015.
http://eprints.ma.man.ac.uk/2344/01/covered/MIMS_ep2014_58.pdf
10. N. Hale, N. J. Higham and L. N. Trefethen, Computing A^α, $\log(A)$ and Related Matrix Functions by Contour Integrals, SIAM J. Numer. Anal., 46 (2008), pp. 2505-2523.
http://eprints.ma.man.ac.uk/1136/01/covered/MIMS_ep2007_103.pdf
11. N. J. Higham and S. Relton, Estimating the Condition Number of the Fréchet Derivative of a Matrix Function, SIAM J. Sci. Comp., 36 (2014), pp. C617-C634.
http://eprints.ma.man.ac.uk/2197/01/covered/MIMS_ep2013_84.pdf
12. M Hochbruck and C. Lubich, On Krylov Subspace Approximations to the Matrix Exponential Operator, SIAM J. Numer. Anal., 34 (1997), pp. 1911-1925.
https://na.math.kit.edu/download/papers/exp.pdf
13. C. Moler and C. Van Loan, Nineteen Dubious Ways to Compute the Exponential of a Matrix, Twenty-Five Years Later, SIAM Rev., 45 (2003), pp. 3-49.
http://www.cs.cornell.edu/cv/researchpdf/19ways+.pdf
14. I. Moret and P. Novati, An Interpolatory Approximation of the Matrix Exponential Based on Faber Polynomials, J. Comput. Appl. Math., 131 (2001), pp. 361-380.
http://www.sciencedirect.com/science/article/pii/S0377042700002612
15. I. Moret and P. Novati, The Computation of Functions of Matrices by Truncated Faber Series, Numer. Funct. Anal. Optimization, 22 (2001), pp. 697-719.
http://www.math.unipd.it/~novati/dati/final_preprints/fsgen4.pdf