Slides at https://langou.github.io/NLA/

CR04: Numerical Linear Algebra
Julien Langou

M2 - Wave #2

Tuesdays 8:00am – 10:00am (A1)
Thursdays 8:00am – 10:00am (B)

Julien Langou, Professor, University of Colorado Denver

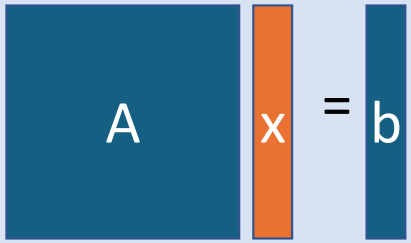
About me

- PhD in 2003 from France, then moved to the US
- 2006-current: Professor at University of Colorado Denver
- 25 years of Research in Numerical Linear Algebra
- Actively contributes to numerical software libraries such as LAPACK.

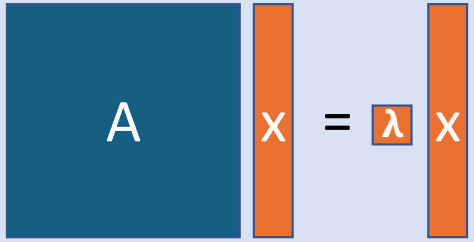
(fast + stable) + (interoperable) + (portable)

Problems to be solved

Linear system of equations



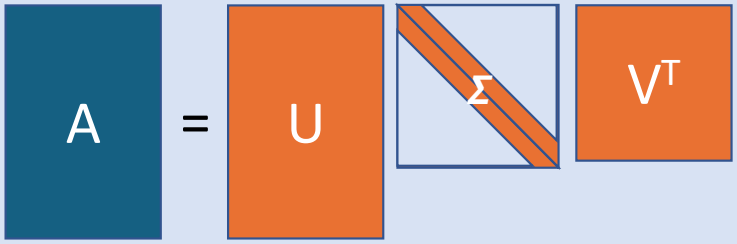
Eigenvalues



Linear Least Squares

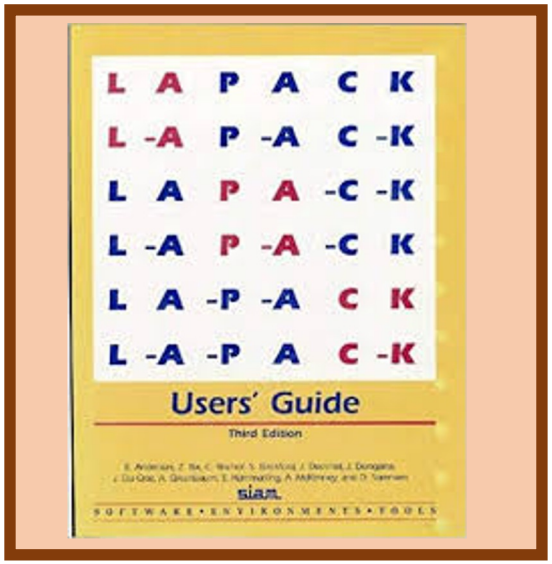
$$\min_x \| b - A x \|_2$$

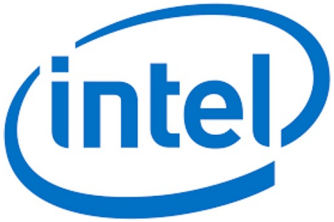
Singular Value Decomposition



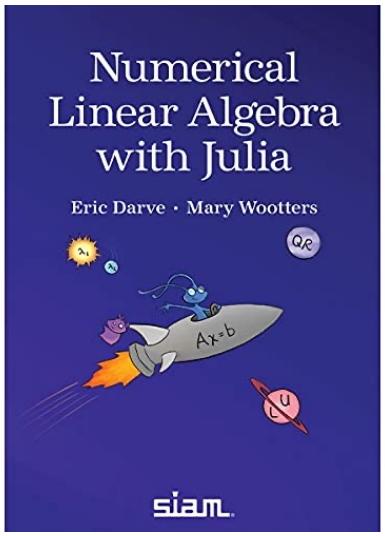
Ecosystem

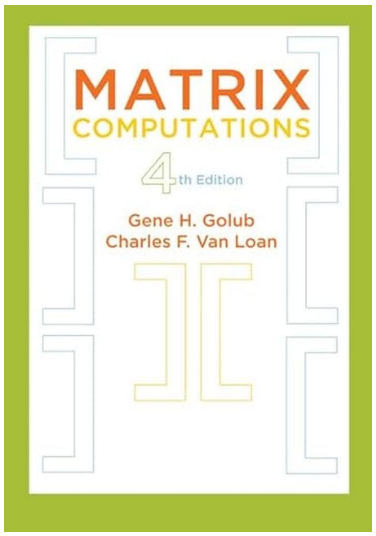
users

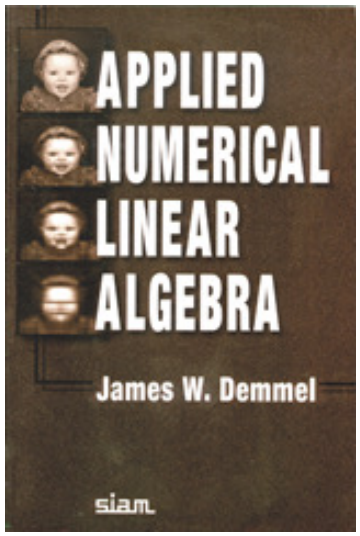




hardware, optimized libraries


Numerical
Linear Algebra
with Julia
Eric Darve · Mary Wootters
Ax=b
siam


MATRIX
COMPUTATIONS
4th Edition
Gene H. Golub
Charles F. Van Loan


APPLIED
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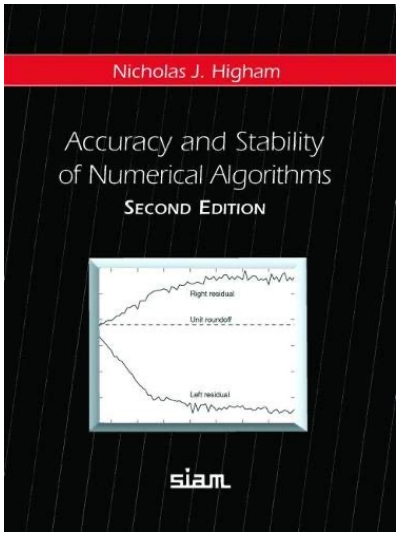
Nicholas J. Higham
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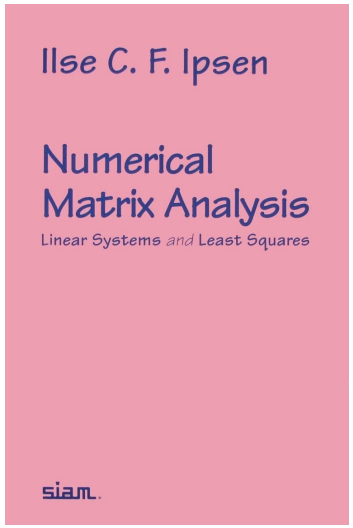
Ilse C. F. Ipsen
Numerical
Matrix Analysis
Linear Systems and Least Squares
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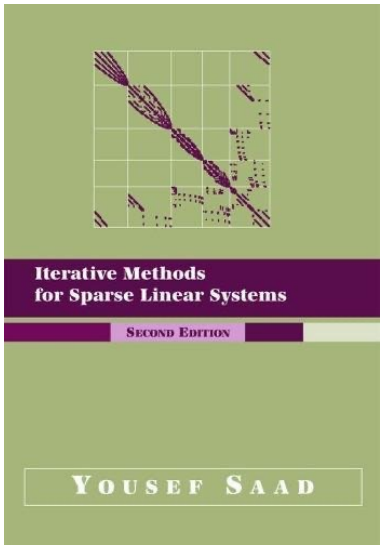
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for Sparse Linear Systems
Second Edition
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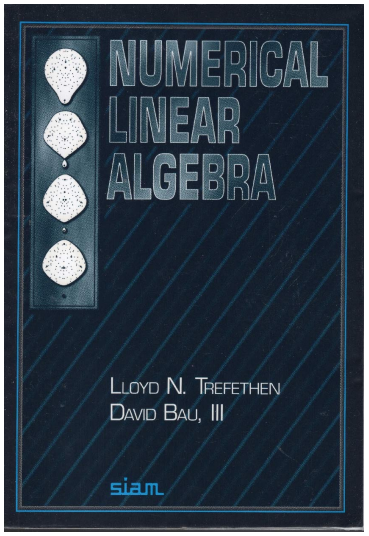
NUMERICAL
LINEAR
ALGEBRA
Lloyd N. Trefethen
David Bau, III
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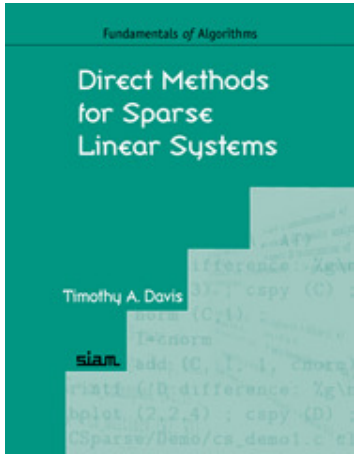
Fundamentals of Algorithms
Direct Methods
for Sparse
Linear Systems
Timothy A. Davis
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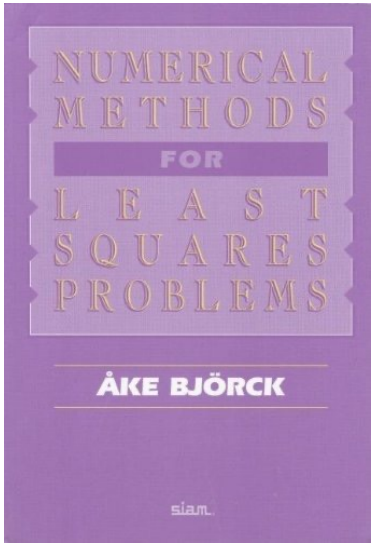
NUMERICAL
METHODS
FOR
LEAST
SQUARES
PROBLEMS
ÅKE BJÖRCK
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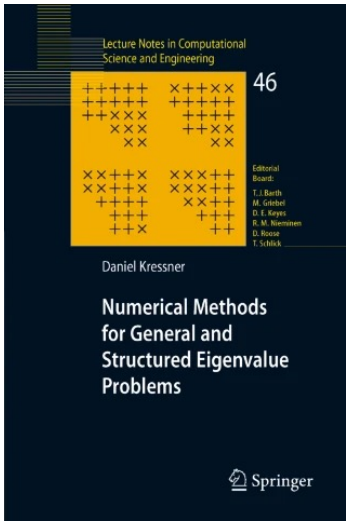
Lecture Notes in Computational
Science and Engineering
46
Daniel Kressner
Numerical Methods
for General and
Structured Eigenvalue
Problems
Springer

24-25 Winter School in Numerical Linear Algebra

- Week 1: Tu. Nov 19 – Th. Nov 21 solving dense linear systems of equations
- Week 2: Tu. Nov 26 – Th. Nov 28 solving dense linear least squares problems
- Week 3: Tu. Dec 3 – Th. Dec 5 introduction to BLAS and parallel implementations (code tuning, I/O, etc.)
- Week 4: Tu. Dec 10 – Th. Dec 12 methods for eigenvalue problems (part 1)
- Week 5: Tu. Dec 17 – Th. Dec 19 methods for eigenvalue problems (part 2)
- Week 6: Tu. Jan 7 – Th. Jan 9 iterative methods for sparse matrices
- Week 7: Tu. Jan 14 – Th. Jan 16 solving sparse linear systems of equations
- Week 8: Tu. Jan 21 – Th. Jan 23 project presentations
- Week 9: Tu. Jan 28 – Th. Jan 30 (slack)

- For each topic, we will review:
  - the problem to be solved,
  - main algorithms to solve the problem
  - condition number, backward error, error analysis
  - efficient implementations, parallel implementation
  - some applications
  - some current research topics will be mentioned

Prerequisites

- Some programing experience in Python, C, Julia, or etc.
- Good understanding of linear algebra

Evaluation

- 50% “contrôle continu” avec DM (Devoir Maison)
- 50% "contrôle terminal” une soutenance de projet

Typical projects

- Write a dense nonsymmetric eigenvalue solver
- Write a dense symmetric eigenvalue solver
- Write a dense singular value solver
- Write a sparse direct solver

Benefits of the class

- Numerical Linear Algebra is used in many applications. It is good to know what are the algorithms behind.

- Some ideas that you can use in many other contexts
  - Code tuning
  - Parallelism
  - Backward stability, error analysis, condition number, etc.