Theo Mary

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Research interests

My research concerns the design, development, and analysis of **high performance, parallel numerical algorithms**. I investigate the use of low-rank approximations and/or mixed precision arithmetic to accelerate such algorithms, in particular the solution of large-scale linear systems. I work on the complexity and error analyses of such methods, as well as their high performance implementation on modern parallel computers.

Short bio

- **Current position** (since Oct. 2019): **CNRS researcher** (chargé de recherche de classe normale) in PEQUAN team at Laboratoire d'Informatique de Paris 6 (LIP6, UMR 7606). Associate member of the APO team at Institut de Recherche en Informatique de Toulouse (IRIT). External member of the NLA group at The University of Manchester.
- **2018–2019:** Postdoctoral research associate at The University of Manchester.
- **2014–2017:** PhD at University of Toulouse, IRIT.

Professional activities

Committees

- Program commitee, International Conference on Parallel Processing (2019–2020).
- Program commitee, Conférence francophone d'informatique en Parallélisme, Architecture et Système (2020–2021).
- Selection commitee, Gilles Kahn PhD thesis prize (2019–2021).

Workshop organization

- 12th *Rencontres Arithmétique de l'Informatique Mathématique* (RAIM 2021, co-organized with T. Hilaire). Registered participants: 83.
- Workshop on *Emerging Algorithms for Large Scale Scientific Computing* (co-organized with L. Halpern and F. Jézéquel). Registered participants: 30. Cancelled due to COVID-19.

Conference minisymposia organization

- *Mixed Precision Algorithms for High Performance Scientific Computing*, **SIAM CSE21** (with S. Pranesh).
- *Advances in Analyzing Floating-point Errors in Computational Science*, **SIAM CSE19** (with P. Blanchard and N. J. Higham).
- *Flat Low-rank Matrix Formats: Potential and Limitations*, **SIAM CSE19** (with G. Pichon).
- *Sparse Direct Solvers for Large-Scale Systems and Applications*, **SIAM CSE17** (with W. Sid-Lakhdar).

Paper reviews

I have reviewed papers for several journals and conferences such as SISC, SIMAX, TOMS, SINUM, IMAJNA, Geophysics, OMS, and ICPP.

Teaching and student supervision

Lectures

- *High Performance Computing* at Sorbonne Université, since 2020.
- Co-organizer of a series of six half-day lectures on *Emerging Algorithms for Large Scale Scientific Computing* (with L. Halpern and F. Jézéquel), 2020.
- *Floating-point Arithmetic and Error Analysis* at Sorbonne Université, since 2019.

- *Large Scale Sparse Linear Algebra* at ENSEEIHT, since 2017.

Students

- **Atef Dorai**, Master student at LIP6 (March 2020–ongoing). Iterative refinement on GPUs.
- **Romeo Molina**, Master student at LIP6 (March 2020–ongoing). Mixed precision SpMV.
- **Matthieu Gerest**, PhD (November 2020–ongoing) and Master (March–November 2020) student at EDF/LIP6, co-advised with F. Jézéquel. Mixed precision block low-rank solvers.
- **Bastien Vieublé**, PhD student at IRIT, co-advised with Alfredo Buttari (October 2019–ongoing). Mixed precision sparse direct solvers.

Software

Most of my software activities revolve around **MUMPS**, a parallel direct solver for sparse linear systems. Being designed for distributed memory computing environments, MUMPS is based on MPI and has a wide range of features that make it reliable and efficient. MUMPS is currently used in several industrial and academic applications and has thousands of users worldwide. My work within MUMPS mainly focuses on its **Block Low-Rank (BLR)** feature, which can reduce its computational cost (time, flops and memory).

Awards

- 2021 SIAG/LA Early Career Prize
- Honorable mention for the Householder Prize XXI (2020).
- Gilles Kahn 2018 prize from the SIF (Société Informatique de France).

Invited plenary presentations at international conferences

For a list of other talks (minisymposia, workshops, seminars, etc.), see my webpage.

- Opportunities for mixed precision arithmetic in numerical linear algebra, at ARITH 2021.
- Exploiting mixed precision arithmetic in the solution of linear systems, at SIAM LA 2021.

Selected publications

For a full list (including conference proceedings, preprints, and others), see my webpage or my Google Scholar profile. Here is a **list of my published journal articles**:

- C. Ashcraft, A. Buttari, and T. Mary. Block Low-Rank Matrices with Shared Bases: Potential and Limitations of the BLR^2 Format. *SIAM J. Matrix Anal. Appl.*, 2021.
- N. J. Higham and T. Mary. Solving Block Low-Rank Linear Systems by LU Factorization is Numerically Stable, *IMA J. Numer. Anal.*, 2021.
- M. Connolly, N. J. Higham, and T. Mary. Stochastic Rounding and its Probabilistic Backward Error Analysis, *SIAM J. Sci. Comput.*, 2021.
- N. J. Higham and T. Mary. Sharper Probabilistic Backward Error Analysis for Basic Linear Algebra Kernels with Random Data, *SIAM J. Sci. Comput.*, 2020.
- P. Blanchard, N. J. Higham, F. Lopez, T. Mary, and S. Pranesh. Mixed Precision Block Fused Multiply-Add: Error Analysis and Application to GPU Tensor Cores. *SIAM J. Sci. Comput.*, 2020.
- P. Blanchard, N. J. Higham, and T. Mary. A Class of Fast and Accurate Summation Algorithms. *SIAM J. Sci. Comput.*, 2020.
- C.-P. Jeannerod, T. Mary, C. Pernet, and D. Roche. Improving the Complexity of Block Low-Rank Factorizations with Fast Matrix Arithmetic, *SIAM J. Matrix Anal. Appl.*, 2019.
- N. J. Higham and T. Mary. A New Approach to Probabilistic Rounding Error Analysis. *SIAM J. Sci. Comput.*, 2019.
- P. R. Amestoy, A. Buttari, J.-Y. L'Excellent, and T. Mary. Bridging the Gap between Flat and Hierarchical Low-rank Matrix Formats: the Multilevel Block Low-Rank Format. *SIAM J. Sci. Comput.*, 2019.
- C. Gorman, G. Chavez, P. Ghysels, T. Mary, F.-H. Rouet, and X. S. Li. Robust and Accurate Stopping Criteria for Adaptive Randomized Sampling in Matrix-Free Hierarchically Semiseparable Construction.

SIAM J. Sci. Comput., 2019.

- N. J. Higham and T. Mary. A New Preconditioner that Exploits Low-Rank Approximations to Factorization Error. *SIAM J. Sci. Comput.*, 2019.
- P. R. Amestoy, A. Buttari, J.-Y. L'Excellent, and T. Mary. Performance and Scalability of the Block Low-Rank Multifrontal Factorization on Multicore Architectures. *ACM Trans. Math. Softw.*, 2019.
- P. R. Amestoy, A. Buttari, J.-Y. L'Excellent, and T. Mary. On the Complexity of the Block Low-Rank Multifrontal Factorization. *SIAM J. Sci. Comput.*, 2017.
- D. Shantsev, P. Jaysaval, S. de la Kethulle de Ryhove, P. R. Amestoy, A. Buttari, J.-Y. L'Excellent, and T. Mary. Large-scale 3D EM modeling with a Block Low-Rank multifrontal direct solver. *Geophysical Journal International*.
- P. Amestoy, R. Brossier, A. Buttari, J.-Y. L'Excellent, T. Mary, L. Métivier, A. Miniussi, and S. Operto. Fast 3D frequency-domain full waveform inversion with a parallel Block Low-Rank multifrontal direct solver: application to OBC data from the North Sea. *Geophysics*, 2016.