Yang Liu

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Research Interests

Scientific Computing: Fast linear solvers for highly oscillatory problems, scalable direct sparse matrix solvers, randomized butterfly algebras, high-performance computing, uncertainty quantification, fast algorithms for machine-learning applications.
Computational Electromagnetics: Fast integral and differential equation solvers for large-scale electromagnetic problems, multi-resolution algorithms for transient scattering, multi-physics and multi-scale modeling.

Research Experience

Research Scientist, Lawrence Berkeley National Laboratory, Aug. 2019 - Present

- Develop autotuning techniques for exascale applications
- Develop efficient direct solver-based RF cavity modeling tools
- Develop GPU and mixed-precision-accelerated sparse linear solvers
- Develop butterfly-based exascale direct solvers for sparse linear systems

Postdoctoral Research Fellow, Lawrence Berkeley National Laboratory, Aug. 2017 - Jul. 2019

- Develop low-rank and butterfly-based hierarchical solvers for highly oscillatory problems.
- Develop scalable triangular solution algorithms for sparse direct solvers.

Postdoctoral Research Fellow, University of Michigan, June 2015 - July 2017

- Develop randomized algorithms for butterfly factorizations and butterfly-based fast direct integral equation solvers for high-frequency Helmholtz problems.

Research Assistant, University of Michigan, Sept. 2010 - May 2015

- Develop provably scalable and wavelet-enhanced plane-wave-time-domain algorithms for integral equation analysis of large-scale transient problems.

Teaching Experience

Lecturer, Exascale Computing Project Annual Meeting, Feb. 2020

- Tutorial: STRUMPACK / SuperLU: fast parallel direct linear solvers and preconditioners

Lecturer, Super Computing, Nov. 2019

- Tutorial: fast parallel direct linear solvers and preconditioners

Lecturer, IEEE NEMO Conference, May 2019

- Tutorial: scalable direct solvers for electromagnetics and multiphysics simulations.

Teaching Assistant, Shanghai Jiao Tong University, Mar. 2009 - June 2009

- Instruct students in FPGA programming for digital circuit designs.

Education

- Ph.D., Electrical Engineering, University of Michigan, May 2015
  Advisor: Eric Michielssen
- M.S., Mathematics, University of Michigan, Nov. 2014
- B.S., Electrical Engineering, Shanghai Jiao Tong University, June 2010

Honors and Awards

- Sergei A. Schelkunoff Transactions Prize Paper Award, IEEE Antennas and Propagation Society, 2018

- 1st Place in Student Paper Competition, 12th International Workshop on Finite Elements for Microwave Engineering, 2014
- 2nd Place in Student Paper Competition, 28th Annual Review of Progress in Applied Computational Electromagnetics, 2012
- Rackham Travel Grant, University of Michigan, 2012 to 2014
- Outstanding Graduate Award, Shanghai Jiao Tong University, 2010
- Third Prize in National Electronic Contest, China, 2009

SOFTWARE DEVELOPMENT

- **ButterflyPACK**, https://github.com/liuyangzhuan/ButterflyPACK
- **GPTune**, https://github.com/gptune/GPTune
- **Superlu_DIST**, https://github.com/xiaoyeli/superlu_dist
- **STRUMPACK**, https://github.com/pghysels/STRUMPACK

JOURNAL REVIEWER

- Journal of Computational Physics
- SIAM Journal of Scientific Computing
- IEEE Transaction on Antennas and Propagation
- IEEE Antennas and Propagation Magazine
- IEEE Transaction on Microwave Theory and Techniques
- IEEE Antennas and Wireless Propagation Letters
- IEEE Journal on Multiscale and Multiphysics Computational Techniques
- International Journal of Numerical Modelling: Electronic Networks, Devices and Fields
- Concurrency and Computation: Practice and Experience
- Journal of Applied Computational Electromagnetics Society
- International Journal of Antennas and Propagation
- The Open Electrical and Electronic Engineering Journal
- Journal of Microwaves, Optoelectronics and Electromagnetic Applications

SESSION ORGANIZER

- Chair for "Low-Rank Compression-Based Fast Sparse Direct Solvers," SIAM Conference on Parallel Processing for Scientific Computing, 2020
- Chair for "Fast and Accurate Integral Methods for Highly Oscillatory Phenomena," SIAM Conference on Computational Science and Engineering, 2019
- Chair for "Time-Domain Computational Methods for Complex Electromagnetic and Multiphysics Problems," IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, 2019
- Chair for "Parallel Sparse Triangular Solve on Emerging Platforms," SIAM Conference on Applied Linear Algebra, 2018
- Chair for "Acceleration Techniques for Integral Equations," IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, 2017.
- Chair for "Time-Domain Numerical Methods," IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, 2012
- Judge for the 10th Annual Engineering Graduate Symposium, University of Michigan, 2015
- Steering Committee for "Celebrating Maxwell's Equations: 150 Years" workshop, 2015.

BOOK CHAPTERS

[1] **Y. Liu**, and E. Michielssen "Parallel fast time-domain integral-equation methods for transient electromagnetic analysis," in Parallel algorithms in computational science and engineering. Birkhauser (in press).

REFEREED JOURNAL PUBLICATIONS

[1] **Y. Liu**, P. Ghysels, L. Claus, and X. Sherry Li "Sparse approximate multifrontal factorization with butterfly compression for high frequency wave equations," *SIAM J. Sci. Comput.,* (arXiv:2007.00202).

[2] **Y. Liu**, Xin Xing, H. Guo, E. Michielssen, P. Ghysels, and X. Sherry Li "Butterfly

factorization via randomized matrix-vector multiplications," *SIAM J. Sci. Comput.,* (arXiv:2002.03400).

[3] **Y. Liu**, W. Sid-Lakhdar, E. Rebrova, P. Ghysels, and X. Sherry Li, "A parallel hierarchical blocked adaptive cross approximation algorithm," *Int. Journal of High Performance Computing Applications* 2020. doi:10.1177/1094342020918305

[4] **Y. Liu**, and H. Yang, "A hierarchical butterfly LU preconditioner for two-dimensional electromagnetic scattering problems involving open surfaces," *J. Comput. Phys.* 2019. doi:10.1016/j.jcp.2019.109014

[5] H. Guo, **Y. Liu**, J. Hu, and E. Michielssen, "A butterfly-based direct solver using hierarchical LU factorization for PMCHWT equations," *Microw. Opt. Technol. Lett.,* 2018. doi:10.1002/mop.31166

[6] **Y. Liu**, A. C. Yucel, H. Bagci, A. C. Gilbert, and E. Michielssen, "Wavelet-enhanced plane-wave time-domain algorithm for analysis of transient scattering from electrically large conducting objects," *IEEE Trans. Antennas Propag.,* 2017. doi:10.1109/TAP.2018.28095

[7] A. C. Yucel, W. Sheng, C. Zhou, **Y. Liu**, H. Bagci, and E. Michielssen, "An FMM-FFT accelerated SIE simulator for analyzing EM wave propagation in mine environments loaded with conductors," *IEEE J. Multiscale and Multiphys. Comput. Techn.,* 2017. doi:10.1109/JMMCT.2018.2802420.

[8] **Y. Liu**, H. Guo, and E. Michielssen, "A HSS matrix-inspired butterfly-based direct solver for analyzing scattering from two-dimensional objects," *IEEE Antennas Wireless Propag. Lett.* 2017. doi:10.1109/LAWP.2016.2626786

[9] H. Guo, **Y. Liu**, J. Hu, and E. Michielssen, "A butterfly-based direct integral equation solver using hierarchical LU factorization for analyzing scattering from large conducting objects," *IEEE Trans. Antennas Propag.,* 2017. doi:10.1109/TAP.2017.2727511

[10] **Y. Liu**, A. Al-Jarro, H. Bagci, and E. Michielssen, "Parallel PWTD-accelerated explicit solution of the time domain electric field volume integral equation," *IEEE Trans. Antennas Propag.,* 2016. doi:10.1109/TAP.2016.2546964

[11] **Y. Liu**, A. C. Yucel, H. Bagci, and E. Michielssen, "A scalable parallel PWTD-accelerated surface integral equation solver for analysis of transient scattering from large-scale objects," *IEEE Trans. Antennas Propag.,* 2016. doi:10.1109/TAP.2015.2508483

[12] **Y. Liu**, A. C. Yucel, V. Lomakin, and E. Michielssen, "Graphics processing unit implementation of multilevel plane-wave time-domain algorithm," *IEEE Antennas Wireless Propag. Lett.,* vol. 1, pp. 1-1, 2014. doi:10.1109/LAWP.2014.2350967

[13] A. C. Yucel, **Y. Liu**, H. Bagci, and E. Michielssen, "Statistical characterization of electromagnetic wave propagation in mine environments," *IEEE Antennas Wireless Propag. Lett.,* vol. 12, pp. 1602-1605, 2013. doi:10.1109/LAWP.2013.2293288

Conference Papers

[1] G. Chavez, E. Rebrova, **Y. Liu**, P. Ghysels and X. S. Li "Scalable and memory-efficient kernel ridge regression," in *34th IEEE International Parallel and Distributed Processing Symposium,* 2020.

[2] Nan Ding, Samuel Williams, **Yang Liu** and X. S. Li "Leveraging one-sided communication for sparse triangular solvers," in *SIAM Workshop on Combinatorial Scientific Computing,* 2020. doi:10.1137/1.9781611976137.9

[3] **Y. Liu**, M. Jacquelin, P. Ghysels, and X. S. Li, "Highly scalable distributed-memory sparse triangular solve algorithms," in *SIAM Workshop on Combinatorial Scientific*

Computing, 2018. doi:10.1137/1.9781611975215.9

[4] E. Rebrova, G. Ghavez, **Y. Liu**, P. Ghysels, and X. S. Li, "A study of clustering techniques and hierarchical matrix formats for kernel ridge regression," in *Proc. IEEE IPDPSW,* 2018. doi:10.1109/IPDPSW.2018.00140

[5] **Y. Liu**, V. Lomakin, and E. Michielssen, "Graphics processing unit-accelerated implementation of the plane wave time domain algorithm," *28th Ann. Rev. Prog. Appl. Computat. Electromagn.,* 2012.

[6] J. Liang, **Y. Liu**, W. Zhang, Y. Xu, X. Gan, and X. Wang, "Joint compressive sensing in wideband cognitive networks," in *IEEE WCNC,* 2010. doi:10.1109/WCNC.2010.5506392

SELECTED PRESENTATIONS

[1] **Y. Liu**, P. Ghysels, and X. S. Li, "Parallel butterfly-based Sherman–Morrison–Woodbury inversion," in *SIAM Conference on Parallel Processing for Scientific Computing,* 2020.

[2] P. Ghysels, **Y. Liu**, and X. S. Li, "Incorporating hierarchical matrix compression and butterfly factorizations in a multifrontal LU solver," in *SIAM Conference on Parallel Processing for Scientific Computing,* 2020.

[3] W. M. Sid-Lakhdar, **Y. Liu**, X. S. Li, O. A. Marques, and J. Demmel, "Autotuning exascale applications," in *SIAM Conference on Parallel Processing for Scientific Computing,* 2020.

[4] **Y. Liu**, "Fast Algebras on Optimized Butterfly Structures," in *SIAM Conference on Computational Science and Engineering,* 2019.

[5] **Y. Liu**, "A blocked adaptive cross approximation algorithm and its hierarchical generalization," in *Copper Mountain Conference On Multigrid Methods,* 2019.

[6] **Y. Liu**, M. Jacquelin, and X. S. Li, "Enhancing scalability of parallel sparse triangular solve in SuperLU," in *SIAM Conference on Applied Linear Algebra,* 2018.

[7] **Y. Liu**, and E. Michielssen, "Parallel butterfly-based direct solvers for highly oscillatory problems," in *SIAM Conference on Parallel Processing for Scientific Computing,* 2018.

[8] **Y. Liu**, H. Guo, and E. Michielssen, "A HSS-type butterfly-based direct integral equation solver for 3D perfect electrically conducting objects," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2017.

[9] **Y. Liu**, H. Guo, and E. Michielssen, "A linear-complexity randomized butterfly scheme for direct integral equation solvers," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2017.

[10] W. Sheng, H. Guo, **Y. Liu**, A. C. Yucel, and E. Michielssen, "A butterfly-based domain decomposition SIE simulator for EM analysis of wireless communication systems in mine environments," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2017.

[11] **Y. Liu**, H. Guo, and E. Michielssen, "A new MLMDA-based direct integral equation solver for electrically perfect conducting objects," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2016.

[12] **Y. Liu**, H. Guo, and E. Michielssen, "A new butterfly reconstruction method for MLMDA-based direct integral equation solvers," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2016.

[13] **Y. Liu**, A. C. Yucel, A. C. Gilbert, H. Bagci, and E. Michielssen, "A wavelet-based PWTD algorithm-accelerated time domain surface integral equation solver," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2015.

[14] **Y. Liu**, A. C. Yucel, H. Bagci, and E. Michielssen, "A parallel wavelet-enhanced PWTD algorithm for analyzing transient scattering from electrically very large PEC targets,"

in *Proc. IEEE Int. Symp. AP-S/URSI,* 2014.

[15] **Y. Liu**, A. C. Yucel, H. Bagci, and E. Michielssen, "Parallel time domain solvers for electrically large transient scattering problems," **invited talk**, in *Proc. EUCAP,* 2014.

[16] A. C. Yucel, L. Gomez, **Y. Liu**, H. Bagci, and E. Michielssen, "A FMM-FFT accelerated hybrid volume surface integral equation solver for electromagnetic analysis of re-entry space vehicles," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2014.

[17] H. Guo, **Y. Liu**, H. Jun, and E. Michielssen, "A parallel MLMDA-based direct integral equation solver," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2013.

[18] A. C. Yucel, **Y. Liu**, H. Bagci, and E. Michielssen, "A fast-multipole domain decomposition integral equation solver for characterizing electromagnetic wave propagation in mine environments," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2013.

[19] **Y. Liu**, H. Bagci, and E. Michielssen, "Solving very large scattering problems using a parallel PWTD-enhanced surface integral equation solver," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2013.

[20] **Y. Liu**, A. Al-Jarro, H. Bagci, and E. Michielssen, "Parallel, explicit, and PWTD-enhanced time domain volume integral equation solver," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2013.

[21] **Y. Liu**, A. C. Yucel, V. Lomakin, and E. Michielssen, "A scalable parallel implementation of the plane wave time domain algorithm on graphics processing unit-augmented clusters," in *Proc. IEEE Int. Symp. AP-S/URSI,* 2012.