

Xiao-Chuan Cai's CV

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□ Education

X.-C. Cai received his BSc degree in 1984 from Peking University, his MSc in 1988 and PhD in 1989 from Courant Institute, New York University.

□ Research Areas

X.-C. Cai's research interests are in the general area of scientific and engineering computing including parallel algorithms and high performance software for linear and nonlinear partial differential equations, domain decomposition methods, multigrid methods, numerical linear algebra, PDE constrained optimizations, inverse problems, stochastic partial differential equations, computational fluid dynamics, fluid-structure interactions, computational biomechanics, and parallel processing.

□ Funding/Honor

1. SIAM Fellow (2016)
2. Highly Scalable Parallel Software Aerodynamic Simulations, National 863 Plan of China, 2015.01-2017.04, PI
3. Highly parallel algorithms for fluid-structure interaction problems and applications, NSFC-RGC funding, 2016.01-2019.12, PI
4. The Study of Implicitly Coupled Space-Time Domain Decomposition Methods with 10^5 Scalability, NSFC, 2014.01-2016.12, PI
5. Application Driven Scalable Parallel Algorithms, The National Key R&D Program, 2016.07-2020.12, Co-PI
6. Clinically Driven High Performance Algorithms for Multi-physics Simulation of Cardiac Dynamics, NSFC-FDCT (Macau) Joint Project, 01/2022 - 12/2024, PI

□ **Selected Publications (2020-2023)**

- [1] Y. Liu, F. Qi, and X.-C. Cai, An aneurysm-specific preconditioning technique for the acceleration of Newton-Krylov method with application in the simulation of blood flow, *International Journal for Numerical Methods in Biomedical Engineering*, (2023).
- [2] Y. Gong, F. Qi, Y. Liu, J.-Y. Wang, T. Ma, Z. Cheng, Y. Jiang, R. Chen, X. Wang, L. Luo, and X.-C. Cai, An interactive platform for a high performance digital twin of a human heart, *IEEE International Conference on Metaverse Computing, Networking and Applications*, (2023).
- [3] S. Li, J. Wang, and X.-C. Cai, A-stable high order block implicit methods for parabolic equations, *SIAM J. Num. Anal.*, (2023).
- [4] Y. Liu and X.-C. Cai, Two-level additive Schwarz methods for three-dimensional unsteady Stokes flows in patient-specific arteries with parameterized one-dimensional central-line coarse preconditioner, *Journal of Computational Physics*, 490 (2023), p. 112290.
- [5] L. Luo and X.-C. Cai, PIN_L: Preconditioned inexact Newton with learning capability for nonlinear system of equations, *SIAM J. Sci. Comput.*, 45 (2023), p. A849-A871.
- [6] Z. Lin, B. Wu, S. Qin, X. Wang, R. Chen, and X.-C. Cai, Numerical calculation of the portal pressure gradient of the human liver with a domain decomposition method, *Domain Decomposition Methods in Science and Engineering XXVI*, (2023), p. 161-168.
- [7] L. Gu, W. Zhang, J. Liu, and X.-C. Cai, Decomposition and preconditioning of deep convolutional neural networks for training acceleration, *Domain Decomposition Methods in Science and Engineering XXVI*, (2023), p. 153-160.
- [8] L. Luo, X.-C. Cai, and D.E. Keyes, A parallel adaptive finite element method for modeling a deformable droplet travelling in air, *Domain Decomposition Methods in Science and Engineering XXVI*, (2023), p. 169-176.
- [9] S. Laudenschlager and X.-C. Cai, An inner-outer subcycling algorithm for parallel cardiac electrophysiology simulations, *International Journal for Numerical Methods in Biomedical Engineering*, 39 (2023), p. e3677.
- [10] S. Qin, R. Chen, B. Wu, and X.-C. Cai, A highly parallel fully implicit domain decomposition method for the simulation of the hemodynamics of a patient-specific artery at the full-body scale, *J. Comput. Phys.*, 472 (2023), p. 111730.
- [11] L. Gu, W. Zhang, J. Liu, and X.-C. Cai, Decomposition and composition of deep convolutional neural networks and training acceleration via sub-network transfer learning, *Electronic Transactions on Numerical Analysis*, 56 (2022), pp. 157-186.
- [12] Z. Yan, Z. Yao, W. Guo, D. Shang, R. Chen, J. Liu, X.-C. Cai, and J. Ge, Impact of the pressure wire on the measured fractional flow reserve and hemodynamics: A combined computational and clinical study, *IEEE Transactions on Biomedical Engineering*, (2022).

- [13] Y. Liu, F. Qi, and X.-C. Cai, A one-dimensional coarse preconditioner for three-dimensional unsteady incompressible Navier-Stokes flows in patient-specific arteries, *SIAM J. Sci. Comput.*, (2022).
- [14] X. Deng, Z.-J. Liao, and X.-C. Cai, An efficient two-level overlapping domain decomposition method for recovering unsteady sources of 3D parabolic problems, *Computers & Mathematics with Applications*, 111 (2022), p. 98-108.
- [15] X. Chen and X.-C. Cai, A recycling preconditioning method with auxiliary tip subspace for elastic crack propagation simulation using XFEM, *Journal of Computational Physics*, 452 (2022), p. 110910.
- [16] L. Liu, F.-N. Hwang, L. Luo, X.-C. Cai, and D.E. Keyes, A nonlinear elimination preconditioned inexact Newton algorithm, *SIAM Journal on Scientific Computing*, 44 (2022), p. A1579-A1605.
- [17] Z. Lin, B. Wu, S. Qin, X. Wang, R. Chen, and X.-C. Cai, Numerical calculation of the portal pressure gradient of the human liver with a domain decomposition method, *Proceedings of the 26th International Conference on Domain Decomposition Methods*, Springer, (2022).
- [18] L. Luo, X.-C. Cai, and D.E. Keyes, A parallel adaptive finite element method for modeling a deformable droplet travelling in air, *Proceedings of the 26th International Conference on Domain Decomposition Methods*, Springer, (2022).
- [19] L. Gu, W. Zhang, J. Liu, and X.-C. Cai, Decomposition and preconditioning of deep convolutional neural networks for training acceleration, *Proceedings of the 26th International Conference on Domain Decomposition Methods*, Springer, (2022).
- [20] Z.-J. Liao, S. Qin, R. Chen, and X.-C. Cai, A parallel domain decomposition method for large eddy simulation of blood flow in human artery with resistive boundary condition, *Computers and Fluids*, 232 (2022), p. 105201.
- [21] J. Xie, Z. Cheng, L. Gu, B. Wu, G. Zhang, W. Shiu, R. Chen, Z. Wang, C. Liu, J. Tu, and X.-C. Cai, Evaluation of cerebrovascular hemodynamics in vascular dementia patients with a new individual computational fluid dynamics algorithm, *Comput. Methods Programs Biomed.*, 213 (2022), p. 106497.
- [22] Z. Yan, R. Chen, and X.-C. Cai, Large eddy simulation of the wind flow in a realistic full-scale urban community with a scalable parallel algorithm, *Comput. Phys. Commun.*, 270 (2022), p. 108170.
- [23] L. Gu and X.-C. Cai, Fusing 2D and 3D convolutional neural networks for the segmentation of aorta and coronary arteries from CT images, *Artif. Intell. Med.*, 121 (2021), pp. 102189.
- [24] S. Qin, B. Wu, J. Liu, W.-S. Shiu, Z. Yan, R. Chen, and X.-C. Cai, Efficient parallel simulation of hemodynamics in patient-specific abdominal aorta with aneurysm, *Comput. Biol. Med.*, 136 (2021), p. 104652.
- [25] X. Deng, Z.-J. Liao, and X.-C. Cai, A parallel multilevel domain decomposition method for source identification problems governed by elliptic equations, *J. Comput. Appl. Math.*, 392 (2021), p. 113441.
- [26] Y. Liu and X.-C. Cai, A central-line coarse preconditioner for Stokes flows in artery-like domains, *Numer. Algorithm*, 1 (2021), pp. 137-160.

- [27] Z. Lin, R. Chen, B. Gao, S. Qin, B. Wu, J. Liu, and X.-C. Cai, A highly parallel simulation of patient-specific hepatic flows, *Inter. J. Numer. Methods Biomed. Eng.*, (2021), p. e3451.
- [28] L. Xu, R. Chen, and X.-C. Cai, Parallel finite-volume discrete Boltzmann method for inviscid compressible flows on unstructured grids, *Phys. Rev. E*, 2 (2021), p. 023306.
- [29] S. Qin, R. Chen, B. Wu, W.-S. Shiu, and X.-C. Cai, Numerical simulation of blood flows in patient-specific abdominal aorta with primary organs, *Biomech. Model. Mechanobiol.*, (2021), pp. 1-16.
- [30] L. Luo, X.-C. Cai, and D.E. Keyes, Nonlinear preconditioning strategies for two-phase flows in porous media discretized by a fully implicit discontinuous Galerkin method, *SIAM J. Sci. Comput.*, 0 (2021), pp. S317-S344.
- [31] J. Li and X.-C. Cai, Summation pollution of principal component analysis and an improved algorithm for location sensitive data, *Numer. Linear Algebra Appl.*, (2021), p. e2370.
- [32] W. Ma and X.-C. Cai, Point-block incomplete LU preconditioning with asynchronous iterations on GPU for multiphysics problems, *Inter. J. High Perf. Comput. Appli.*, 2 (2020), pp. 121-135.
- [33] Y. Jiang, R. Chen, and X.-C. Cai, A highly parallel implicit domain decomposition method for the simulation of the left ventricle on unstructured meshes, *Comput. Mech.*, 6 (2020), pp. 1461-1475.
- [34] R. Chen, B. Wu, Z. Cheng, W.-S. Shiu, J. Liu, L. Liu, Y. Wang, X. Wang, and X.-C. Cai, A parallel non-nested two-level domain decomposition method for simulating blood flows in cerebral artery of stroke patient, *Inter. J. Numer. Methods Biomed. Eng.*, 11 (2020), p. e3392.
- [35] L. Luo, L. Liu, X.-C. Cai, and D.E. Keyes, Fully implicit hybrid two-level domain decomposition algorithms for two-phase flows in porous media on 3D unstructured grids, *J. Comput. Phys.*, 409 (2020), p. 109312.
- [36] L. Luo, X.-C. Cai, Z. Yan, L. Xu, and D.E. Keyes, A multilayer nonlinear elimination preconditioned inexact Newton method for steady-state incompressible flow problems in three dimensions, *SIAM J. Sci. Comput.*, 6 (2020), pp. B1404-B1428.