

Helen Xu

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Research Summary

I study theoretically and practically efficient parallel algorithms because as Moore's law ends, efficient algorithms will be one of the major ways to gain performance for new applications. In particular, I have recently investigated in sparse graph and tensor problems because of their ubiquity and susceptibility to mathematical analysis.

Current Position

Mar 2022 - Present **Grace Hopper Postdoctoral Scholar in Computing Sciences**, Lawrence Berkeley National Laboratory.
Host: Dr. Aydın Buluç.

Education

Feb 2022 **Ph.D. in Computer Science**, Massachusetts Institute of Technology.
Thesis: The Locality-First Strategy for Developing Efficient Multicore Algorithms.
Advisor: Prof. Charles E. Leiserson.

May 2016 **B.S. with Honors in Computer Science**, Stony Brook University.
Thesis: Write-optimized Skip Lists.
Advisor: Prof. Michael A. Bender.
Awards: Ranked first in the 2016 graduating class of over 100 students and received the Undergraduate Teaching Assistant Award (top 1% of TAs in the CS department).

Publications

Published 14 peer-reviewed conference papers (10 full papers and 4 short papers) in top venues for systems and algorithms including SIGMOD, PODS, SPAA, and IPDPS.

Conference Publications

- ALENEX '23 *Optimizing Search Layouts in Packed Memory Arrays*. Brian Wheatman, Randal Burns, Aydın Buluç, and **Helen Xu**. To appear at the SIAM Symposium on Algorithm Engineering and Experiments (ALENEX), 2023.
- ESA '22 *When Are Cache-Oblivious Algorithms Cache Adaptive? A Case Study of Matrix Multiplication and Sorting*. Arghya Bhattacharya, **Helen Xu**, Abiyaz Chowdhury, Rathish Das, Rezaul A. Chowdhury, Rob Johnson, Rishab Nithyanand, Michael A. Bender. In European Symposium on Algorithms, 2022.
- ACDA '21 *Multidimensional Included and Excluded Sums*. **Helen Xu**, Sean Fraser, and Charles E. Leiserson. In SIAM Conference on Applied and Computational Discrete Algorithms, 2021.
- SIGMOD '21 *Terrace: A Hierarchical Graph Container for Skewed Dynamic Graphs*. Prashant Pandey, Brian Wheatman, **Helen Xu**, and Aydın Buluç. In ACM SIGMOD International Conference on Management of Data, 2021.

- ALLENEX '21 *A Parallel Packed Memory Array to Store Dynamic Graphs*. Brian Wheatman and **Helen Xu**. In SIAM Symposium on Algorithm Engineering and Experiments, 2021.
- APOCS '21 *Beyond Worst-case Analysis of Multicore Caching Strategies*. (in alphabetical order) Shahin Kamali and **Helen Xu**. In SIAM Symposium on Algorithmic Principles of Computer Systems, 2021.
- SPAA '20 *Closing the Gap Between Cache-Oblivious and Cache-Adaptive Analysis*. (in alphabetical order) Michael A. Bender, Rezaul A. Chowdhury, Rathish Das, Rob Johnson, William Kuszmaul, Andrea Lincoln, Quanquan C. Liu, Jayson Lynch, and **Helen Xu**. In ACM Symposium on Parallelism in Algorithms and Architectures, 2020.
- SPAA '18 *Cache-Adaptive Exploration: Experimental Results and Scan-Hiding for Adaptivity*. (in alphabetical order) Andrea Lincoln, Quanquan C. Liu, Jayson Lynch, and **Helen Xu**. In ACM Symposium on Parallelism in Algorithms and Architectures, 2018.
- IPDPS '18 *A Fill Estimation Algorithm for Sparse Matrices and Tensors in Blocked Formats*. Peter Ahrens, **Helen Xu**, and Nicholas Schiefer. In IEEE International Parallel and Distributed Processing Symposium, 2018.
- PODS '17 *Write-Optimized Skip Lists*. (in alphabetical order) Michael A. Bender, Martin Farach-Colton, Rob Johnson, Simon Mairas, Tyler Mayer, Cynthia Phillips, and **Helen Xu**. In ACM Symposium on Principles of Database Systems, 2017.

Peer-Reviewed Short Publications

- HPEC '20 *Work-Efficient Parallel Algorithms for Accurate Floating-Point Prefix Sums*. Sean Fraser, **Helen Xu**, and Charles E. Leiserson. In IEEE High Performance Extreme Computing Conference, 2020.
- SPAA '20 *Brief Announcement: Multicore Paging Algorithms Cannot Be Competitive*. (in alphabetical order) Shahin Kamali and **Helen Xu**. In ACM Symposium on Parallelism in Algorithms and Architectures, 2020.
- ICONS '19 *Dynamic Programming with Spiking Neural Computing*. (in alphabetical order) James Aimone, Ojas Parekh, Cynthia Phillips, Ali Pinar, William Severa, and **Helen Xu**. In International Conference on Neuromorphic Systems, 2019.
- HPEC '18 *Packed Compressed Sparse Row: A Dynamic Graph Representation*. Brian Wheatman and **Helen Xu**. In IEEE High Performance Extreme Computing Conference, 2018.

Preprints

A Compressed Packed Memory Array with Fast Parallel Batch Updates. Brian Wheatman and Randal Burns and Aydın Buluç and **Helen Xu**.

Awards

- 2022 **Grace Hopper Fellowship in Computing Sciences** for two years of postdoctoral study at Berkeley Lab.
- 2022 **Argonne Training Program for Extreme-Scale Computing (ATPESC)**, a fully-funded two-week course on high-performance computing (awarded to about 80 researchers).
- 2021 **Finalist for Best Student Presentation at ACDA 2021**.
- 2020 **Rising Stars Workshop** held virtually at UC Berkeley.
- 2020 **Chateaubriand Fellowship** for Spring 2020 at ENS Lyon.
- 2016 **National Physical Science Consortium (NPSC) Graduate Fellowship**, awarded for six years of graduate study.

- 2016 **Undergraduate Teaching Assistant Award**, awarded to around 1% of TAs in the department of Computer Science at Stony Brook University.
- 2015 **NSF Research Experience for Undergraduates Supplement**, awarded for one year of undergraduate research.
- 2013-2016 **Christian Mata Scholarship for Excellence in Computer Science**, awarded to the top ranked computer science student in every year at Stony Brook University.

Research Experience

- Sep 2016 - Feb 2022 **Supertech Group** *Massachusetts Institute of Technology*, Cambridge, MA.
Designed, analyzed, and implemented parallel and cache-friendly algorithms for shared-memory multicores.
Mentor: Prof. Charles E. Leiserson.
- Summer 2020 **Architecture Research Group** *NVIDIA Research*, Westford, MA.
Created and evaluated compressed data structures for sparse tensor computations.
Mentor: Dr. Michael Pellauer.
- Spring 2020 **Resource Optimization: Models, Algorithms, and Scheduling Group** *ENS Lyon*, Lyon, France.
Studied algorithms for multi-resource job scheduling with theoretical guarantees.
Mentors: Professors Loris Marchal, Frederic Vivien, and Anne Benoit.
- Summer 2019 **Systems and Networking Group** *Microsoft Research*, Cambridge, UK.
Developed and implemented algorithms for novel parallel machine learning accelerators.
Mentor: Dr. Nuno Lopes.
- Summer 2016 **Discrete Mathematics and Optimization Group** *Sandia National Laboratories*, Albuquerque, NM.
Simplified and refined randomized I/O-efficient data structures.
Mentor: Dr. Cindy Phillips
- Summer 2015 **Systems and Security Research Group** *Sandia National Laboratories*, Livermore, CA.
Designed and implemented a network event tracking database using an existing write-optimized fractal tree index.
Mentor: Dr. Tom Kroeger

Teaching

Qualifications

- 2021 **Kaufman Teaching Certificate Program (KTCP)** *Teaching and Learning Lab*, Massachusetts Institute of Technology, Cambridge, MA.
- Completed a semester-long course consisting of developing teaching skills via weekly workshops.
 - Prepared and delivered a teaching demo on algorithms to a general audience and provided peer feedback.

Experience

- 2017 - 2018 **Teaching Assistant for Performance Engineering of Software Systems** *Department of Electrical Engineering and Computer Science*, Massachusetts Institute of Technology, Cambridge, MA.
- Received an average overall rating of 6.2 out of 7 points.
 - Led weekly recitations (TA-led tutorial sessions) and office hours.
 - Developed the course cloud infrastructure, including the course development environment and tools suite.
 - Coordinated with instructors to write and grade homeworks and exams.
 - Helped students with assignments on the course discussion forum.

2014 - 2015 **Teaching Assistant for Discrete Mathematics** *Department of Computer Science, Stony Brook University, Stony Brook, NY.*

Students Advised

Ph.D.

2018-present **Brian Wheatman**, Johns Hopkins University (hosted at Berkeley Lab in Summer 2022).

Compressed Dynamic Data Structures for Efficient Graph Processing.

2020-present **Arghya Bhattacharya**, Stony Brook University.

An Experimental Evaluation of Cache-Adaptive Algorithms.

Masters theses

Feb 2023 **Amanda Li**, MIT.

(expected) Efficient Dynamic Graph Processing via Data Structure Design.

June 2020 **Sean Fraser**, MIT.

Optimizing Parallel Prefix Sums for Scientific Computing.

June 2019 **Brian Wheatman**, MIT (co-advised with Tim Kaler).

Image Alignment and Dynamic Graph Analytics : Two Case Studies of How Managing Data Movement Can Make (Parallel) Code Run Fast.

June 2019 **Stephanie Ren**, MIT (co-advised with Tao B. Schardl).

Vector-Aware Space Cuts in Stencil Computations.

Technical Talks and Presentations

Invited Seminars

Optimizing Dynamic Graph Processing on Multicores with the Locality-First Strategy

- Lawrence Berkeley National Laboratory, 2022.

Data Structure Design for Skewed Dynamic Graphs

- MIT Fast Code Seminar, 2021.
- Williams CS Colloquium, 2021.

Updatable Data Compression Formats for Hierarchical Fiber Abstraction

- NVIDIA Research, 2020.

A Fill-Estimation Algorithm for Sparse Matrices and Tensors in Blocked Formats

- Tel Aviv University, 2019.

Conference Talks

Multidimensional Included and Excluded Sums

- *Finalist for Best Student Presentation* at ACDA, 2021.

Beyond Worst-case Analysis of Multicore Caching Strategies

- APOCS, 2021.

Work-Efficient Parallel Algorithms for Accurate Floating-Point Prefix Sums

- HPEC, 2020.

Multicore Paging Algorithms Cannot Be Competitive

- SPAA, 2020.

Dynamic Time Warping in Strongly Subquadratic Time: Algorithms for the Low-Distance Regime and Approximate Evaluation

- ICALP, 2019 (filling in for Bill Kuszmaul).

Cache-Adaptive Exploration: Experimental Results and Scan-Hiding for Adaptivity

- SPAA, 2018.

Write-Optimized Skip Lists

- PODS, 2017 (Joint talk with Tyler Mayer).
- Guest lecture in MIT's advanced performance engineering course (MIT 6.S898), 2017.

Posters

A Parallel Packed Memory Array for Dynamic Graphs

- Rising Stars Poster Session, 2020.

A Fill-Estimation Algorithm for Sparse Matrices and Tensors in Blocked Formats

- CSAIL Alliances Poster Session, 2018.

Performance Engineering Discussions

Software Performance Engineering at the End of Moore's Law

- Jane Street Symposium, 2020.

Leisearch Codewalk

- Guest lecture in Performance Engineering of Software Systems (MIT 6.172), 2018.

Communication Workshops

NSF Graduate Research Fellowship Statements Workshop

- MIT EECS Communication Lab, 2020 and 2021.

Research Qualifying Examination Workshop

- MIT EECS Communication Lab, 2019 and 2021.

Professional Service

2022-present **Program Committee Member** for *ALLENEX* (2022, 2023), *SPAA* (2022, 2023), *SEA* (2023).

2018-present **Paper Reviewer** for *BigData* (2023), *JPDC* (2022), *ICPP* (2021), *ACDA* (2021), *WADS* (2021), *SPAA* (2021, 2020), *EuroPar* (2020), *SOSA* (2020), *SODA* (2019, 2018), *ESA* (2019, 2022).

2023 **Availability Reviewer** for *SIGMOD*

2018 - 2022 **Communication Lab Advisor** with the MIT Electrical Engineering and Computer Science Communications Lab.

Communication Lab Page: <http://mitcommlab.mit.edu/eecs/>

- Reviewed over 50 papers, talks, statements, and CVs via peer coaching.
- Created and implemented a partnership with Professor Saman Amarasinghe's research group to jointly prepare conference presentations via weekly meetings.
- Prepared and led workshops for the NSF Graduate Research Fellowship application (2020, 2021) and the PhD research qualifying exam presentation (2019, 2021).
- Wrote articles about core technical communications topics, such as thesis proposals and paper abstracts.

2017 **Co-president** of MIT Graduate Women in Course 6 (GW6).

Webpage: <http://gw6.scripts.mit.edu/>

- Organized events several times per month for graduate women in the department, including professional development and social activities.

References

Prof. Charles E. Leiserson

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