Tyler H. Chang

Mathematics and Computer Science Division, Argonne National Laboratory

tchang@anl.gov 9700 S. Cass Ave, Bldg. 240, Lemont, IL 60439
https://thchang.github.io https://github.com/thchang

Interests

Blackbox optimization, scientific machine learning, approximation theory, computational geometry, and scientific software

Education

Ph.D., May 2020, Computer Science, Virginia Polytechnic Institute & State University (Virginia Tech)
- *Advisor: Layne Watson*
- *Dissertation: Mathematical Software for Multiobjective Optimization Problems*

B.S., May 2016, Computer Science & Mathematics (double-major), Virginia Wesleyan University
- *Summa cum laude; 2x ACM ICPC site champion; 8x Dean's list; 4x all-ODAC (conference) for varsity tennis*

Research Experience

Jun 2020 - Present. **Postdoctoral appointee: Argonne National Laboratory**, MCS Division
- Designed and implemented a Python framework for building and deploying multiobjective optimization solvers
- Deployed solvers for particle accelerator design, autonomous material discovery, and neural-network architecture search

Aug 2016 - May 2020. **Cunningham fellow: Virginia Tech**, Dept. of Computer Science
- Designed parallel algorithms and software for predicive modeling, blackbox optimization, and computational geometry
- Applied solvers to model and tune HPC systems to control performance variability

Jun 2019 - Dec 2019. **SCGSR awardee: Argonne National Laboratory**, MCS Division
- Conducting research in multiobjective optimization software via DOE SCGSR program (see awards)

Feb 2016 - Aug 2016. **Research assistant: Old Dominion University**, Dept. of Computer Science
- Aided in parallelizing NASA's FUN3D CFD kernel on NVIDIA GPUs using CUDA and MPI

Dec 2015 - Jan 2016. **Intern: US Army Research Labs**, Computational Science Division
May 2015 - Aug 2015. **Intern: US Army Research Labs**, Computational Science Division
- Accelerating software for real-time optimal control (summer) & using AR technology for info viz (winter)

Dec 2014 - Jan 2015. **Intern: US Army Research Labs**, Guidance Technology Branch
May 2014 - Aug 2014. **Intern: US Army Research Labs**, Guidance Technology Branch
- Using OpenCV for real-time sensing (summer) & developing software for embedded systems (winter)

Awards

2021. **Nominee for Outstanding Dissertation Award: Virginia Tech**, Graduate School
2019. **Davenport Leadership Fellowship: Virginia Tech**, College of Engineering
2018. **SCGSR Award: DOE Office of Science**, Graduate Student Research (SCGSR) Program
2018. **Pratt Fellowship: Virginia Tech**, College of Engineering
2017. **Pratt Fellowship: Virginia Tech**, College of Engineering
2016. **Cunningham Doctoral Fellowship: Virginia Tech**, Graduate School
2016. **Davenport Leadership Fellowship: Virginia Tech**, College of Engineering
2016. **Outstanding Student in Computer Science & Mathematics: Virginia Wesleyan University**

Publicly Available Software

4. 2023. **ParMOO**: Python library for parallel multiobjective simulation optimization. Release: 0.2.2
   Devs: **T. H. Chang** (lead), S. M. Wild, and H. Dickinson[1] Primary Prog. Lang: `Python 3`
   `git:` https://github.com/parmoo/parmoo
3. 2022. **VTMOP**: Solver for blackbox multiobjective optimization problems.
   Devs: **T. H. Chang** (sole) Primary Prog. Lang: `Fortran 2008`
   `git:` https://github.com/vtopt/VTMOP
2. 2020. **DelaunaySparse**: Interpolation via a sparse subset of the Delaunay triangulation.
   Devs: **T. H. Chang** (lead) and T. C. H. Lux Primary Prog. Lang: `Fortran 2003`
   `git:` https://github.com/vtopt/DelaunaySparse
1. 2019. **QAML**: Quantum annealing math library.
   Devs: T. C. H. Lux (lead), **T. H. Chang**, and S. S. Tipirneni Primary Prog. Lang: `Python 3`
   `git:` https://github.com/tchlux/qaml

Publications

Publications In-Press

1. M. Garg[2], **T. H. Chang**, and K. Raghavan. SF-SFD: Stochastic optimization of Fourier coefficients for space-filling designs. To appear in 2023 Winter Simulation Conference (WSC 2023).

Publications Under Review

1. **T. H. Chang** and S. M. Wild. Designing a framework for solving multiobjective simulation optimization problems. Submitted to Advances in Engineering Software, Apr 2023. Preprint: https://arxiv.org/abs/2304.06881.

Peer-Reviewed Journal Articles

10. 2023. T. C. H. Lux, L. T. Watson, **T. H. Chang**, and W. I. Thacker. Algorithm 1031: MQSI—Monotone quintic spline interpolation. *ACM Transactions on Mathematical Software* 49(1), Article 6, 17 pages. `doi:` 10.1145/3570157
9. 2023. **T. H. Chang** and S. M. Wild. ParMOO: a Python library for parallel multiobjective simulation optimization. *Journal of Open Source Software* 8(82), Article 4468, 5 pages. `doi:` 10.21105/joss.04468
8. 2023. N. Neveu, **T. H. Chang**, P. Franz, S. Hudson, and J. Larson. Comparison of multiobjective optimization methods for the LCLS-II photoinjector. *Computer Physics Communication* 283, Article 108566, 10 pages. `doi:` 10.1016/j.cpc.2022.108566
7. 2023. Y. Wang, L. Xu, Y. Hong, R. Pan, **T. H. Chang**, T. C. H. Lux, J. Bernard, L. T. Watson, and K. W. Cameron. Design strategies and approximation methods for high-performance computing variability management. *Journal of Quality Technology* 55(1), pp. 88–103. `doi:` 10.1080/00224065.2022.2035285
6. 2022. **T. H. Chang**, L. T. Watson, J. Larson, N. Neveu, W. I. Thacker, S. Deshpande, and T. C. H. Lux. Algorithm 1028: VTMOP: Solver for blackbox multiobjective optimization problems. *ACM Transactions on Mathematical Software* 48(3), Article 36, 34 pages. `doi:` 10.1145/3529258
5. 2021. L. Xu, T. C. H. Lux, **T. H. Chang**, B. Li, Y. Hong, L. T. Watson, A. R. Butt, D. Yao, and K. W. Cameron. Prediction of high-performance computing input/output variability and its application to optimization for system configurations. *Quality Engineering* 33(2), pp. 318–334. `doi:` 10.1080/08982112.2020.1866203
4. 2021. T. C. H. Lux, L. T. Watson, **T. H. Chang**, J. Bernard, B. Li, L. Xu, G. Back, A. R. Butt, K. W. Cameron, and Y. Hong. Interpolation of sparse high-dimensional data. *Numerical Algorithms* 88(1), pp. 281–313. `doi:` 10.1007/s11075-020-01040-2
3. 2020. **T. H. Chang**, L. T. Watson, T. C. H. Lux, A. R. Butt, K. W. Cameron, and Y. Hong. Algorithm 1012: DELAUNAYSPARSE: Interpolation via a sparse subset of the Delaunay triangulation in medium to high dimensions. *ACM Transactions on Mathematical Software* 46(4), Article 38, 20 pages. `doi:` 10.1145/3422818
2. 2020. L. Xu, Y. Wang, T. C. H. Lux, **T. H. Chang**, J. Bernard, B. Li, Y. Hong, K. W. Cameron, and L. T. Watson. Modeling I/O performance variability in high-performance computing systems using mixture distributions. *Journal of Parallel and Distributed Computing* 139, pp. 87–98. `doi:` 10.1016/j.jpdc.2020.01.005
1. 2019. **T. H. Chang**, T. C. H. Lux, and S. S. Tipirneni. Least-squares solutions to polynomial systems of equations with quantum annealing. *Quantum Information Processing* 18(12), Article 374, 17 pages. `doi:` 10.1007/s11128-019-2489-x

Peer-Reviewed Conference Papers

13. 2023. **T. H. Chang**, J. R. Elias, S. M. Wild, S. Chaudhuri, and J. A. Libera. A framework for fully autonomous design of materials via multiobjective optimization and active learning: challenges and next steps. *In 11th Intl. Conf. on Learning Representation (ICLR 2023), Workshop on Machine Learning for Materials (ML4Materials)*. Kigali, Rwanda. `url:` https://openreview.net/forum?id=8KJS7RPjMqG

[1]= DOE SULI at Argonne in my supervision
[2]= NSF MSGI at Argonne in my supervision

12. 2020. **T. H. Chang**, J. Larson, and L. T. Watson. Multiobjective optimization of the variability of the high-performance Linpack solver. *In Proc. 2020 Winter Simulation Conference (WSC 2020)*, pp. 3081–3092. Orlando, FL, USA. **doi:** 10.1109/WSC48552.2020.9383875
11. 2020. **T. H. Chang**, J. Larson, L. T. Watson, and T. C. H. Lux. Managing computationally expensive blackbox multiobjective optimization problems with libEnsemble. *In Proc. 2020 Spring Simulation Conference (SpringSim '20)*, Article 31, 12 pages. Fairfax, VA, USA. **doi:** 10.22360/springsim.2020.hpc.001
10. 2020. T. C. H. Lux, L. T. Watson, **T. H. Chang**, L. Xu, Y. Wang, and Y. Hong. An algorithm for constructing monotone quintic interpolating splines. *In Proc. 2020 Spring Simulation Conference (SpringSim '20)*, Article 33, 12 pages. Fairfax, VA, USA. **doi:** 10.22360/springsim.2020.hpc.003
9. 2020. T. C. H. Lux and **T. H. Chang**. Analytic test functions for generalizable evaluation of convex optimization techniques. *In Proc. IEEE SoutheastCon 2020*, 8 pages. Raleigh, NC, USA. **doi:** 10.1109/SoutheastCon44009.2020.9368254
8. 2020. T. C. H. Lux, L. T. Watson, **T. H. Chang**, L. Xu, Y. Wang, J. Bernard, Y. Hong, and K. W. Cameron. Effective nonparametric distribution modeling for distribution approximation applications. *In Proc. IEEE SoutheastCon 2020*, 6 pages. Raleigh, NC, USA. **doi:** 10.1109/SoutheastCon44009.2020.9368295
7. 2018. **T. H. Chang**, L. T. Watson, T. C. H. Lux, S. Raghvendra, B. Li, L. Xu, A. R. Butt, K. W. Cameron, and Y. Hong. Computing the umbrella neighbourhood of a vertex in the Delaunay triangulation and a single Voronoi cell in arbitrary dimension. *In Proc. IEEE SoutheastCon 2018*, 8 pages. St. Petersburg, FL, USA. **doi:** 10.1109/SECON.2018.8479003
6. 2018. T. C. H. Lux, L. T. Watson, **T. H. Chang**, J. Bernard, B. Li, X. Yu, L. Xu, G. Back, A. R. Butt, K. W. Cameron, Y. Hong, and D. Yao. Nonparametric distribution models for predicting and managing computational performance variability. *In Proc. IEEE SoutheastCon 2018*, 7 pages. St. Petersburg, FL, USA. **doi:** 10.1109/SECON.2018.8478814
5. 2018. **T. H. Chang**, L. T. Watson, T. C. H. Lux, J. Bernard, B. Li, L. Xu, G. Back, A. R. Butt, K. W. Cameron, and Y. Hong. Predicting system performance by interpolation using a high-dimensional Delaunay triangulation. *In Proc. 2018 Spring Simulation Conference (SpringSim '18)*, Article 2, 12 pages. Baltimore, MD, USA. **doi:** 10.22360/springsim.2018.hpc.003
4. 2018. T. C. H. Lux, L. T. Watson, **T. H. Chang**, J. Bernard, B. Li, L. Xu, G. Back, A. R. Butt, K. W. Cameron, and Y. Hong. Predictive modeling of I/O characteristics in high performance computing systems. *In Proc. 2018 Spring Simulation Conference (SpringSim '18)*, Article 8, 10 pages. Baltimore, MD, USA. **doi:** 10.22360/springsim.2018.hpc.009
3. 2018. **T. H. Chang**, L. T. Watson, T. C. H. Lux, B. Li, L. Xu, A. R. Butt, K. W. Cameron, and Y. Hong. A polynomial time algorithm for multivariate interpolation in arbitrary dimension via the Delaunay triangulation. *In Proc. 2018 ACM Southeast Conference (ACMSE '18)*, Article 12, 8 pages. Richmond, KY, USA. **doi:** 10.1145/3190645.3190680
2. 2018. T. C. H. Lux, L. T. Watson, **T. H. Chang**, J. Bernard, B. Li, X. Yu, L. Xu, G. Back, A. R. Butt, K. W. Cameron, D. Yao, and Y. Hong. Novel meshes for multivariate interpolation and approximation. *In Proc. 2018 ACM Southeast Conference (ACMSE '18)*, Article 13, 7 pages. Richmond, KY, USA. **doi:** 10.1145/3190645.3190687
1. 2017. C. Raghunath, **T. H. Chang**, L. T. Watson, M. Jrad, R. K. Kapania, and R. M. Kolonay. Global deterministic and stochastic optimization in a service oriented architecture. *In Proc. 2017 Spring Simulation Conference (SpringSim '17)*, Article 7, 12 pages. Virginia Beach, VA, USA. **doi:** 10.22360/springsim.2017.hpc.023

Technical Reports and Dissertations

4. 2023. **T. H. Chang**, S. M. Wild, and H. Dickinson[1]. *ParMOO: Python library for parallel multiobjective simulation optimization*. Technical Report Version 0.2.2. Argonne National Laboratory, Lemont, Illinois, USA. **url:** https://parmoo.readthedocs.io/_/downloads/en/latest/pdf/
3. 2020. A. K. Gillette and **T. H. Chang**. *ALGORITHMS: assessing latent space dimension by Delaunay loss*. Technical Report LLNL-CONF-814930. Lawrence Livermore National Laboratory, Livermore, California, USA. **url:** https://www.osti.gov/servlets/purl/1756748
2. 2020. **T. H. Chang**. *Mathematical software for multiobjective optimization problems*. Ph.D. Dissertation. Department of Computer Science, Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg, VA, USA. **Dept. of Computer Science Nominee for Outstanding Dissertation Award**. **url:** http://hdl.handle.net/10919/98915
1. 2016. **T. H. Chang**. *GPU saturation for multiple matrix-vector multiplications*. Bachelor's Thesis. Department of Computer Science, Virginia Wesleyan University, Virginia Beach, VA, USA.

Talks and Presentations

Invited Conference Talks

5. Jun 2023. Exploiting structures in multiobjective simulation optimization problems. *SIAM Conference on Optimization (OP 2023)*, Seattle, WA, USA.
4. Mar 2023. ParMOO: a Python library for parallel multiobjective simulation optimization. *SIAM Conference on Computational Science and Engineering (CSE 2023)*, Amsterdam, Netherlands.
3. Sep 2022. Geometric considerations when surrogate modeling. *SIAM Conference on Mathematics of Data Science (MDS 2022)*, San Diego, CA, USA.
2. Jul 2021. Surrogate modeling of simulations for multiobjective optimization applications. *SIAM Conference on Optimization (OP 2021)*, virtual event.

1. Mar 2021. Computing sparse subsets of the Delaunay triangulation in high-dimensions for interpolation and graph problems. *SIAM Conference on Computational Science and Engineering (CSE 2021)*, virtual event.

Seminars and Colloquia

3. Feb 2020. Algorithms and software for Delaunay interpolation and multiobjective optimization. *Sandia National Laboratory, Wind Energy Technology Division Seminar*, virtual event.
2. Feb 2020. Algorithms and software for Delaunay interpolation and multiobjective optimization. *Argonne National Laboratory, Mathematics and Computer Science Division Seminar*, Lemont, IL, USA.
1. Jan 2020. Algorithms and software for Delaunay interpolation and multiobjective optimization. *Sandia National Laboratory, Center for Computing Research Seminar*, Albuquerque, NM, USA.

Tutorials and Guest Lectures

2. Oct 2022. An introduction to multiobjective simulation optimization with ParMOO. *The Science Academy, Science Circle Cohort, guest speaker*, virtual event. Recording: https://www.youtube.com/watch?v=gQha8URLEHM.
1. May 2022. An introduction to multiobjective simulation optimization with ParMOO. *Univeristy of Chicago, Pritzker School of Molecular Engineering, guest lecture*, virtual event.

Contributed Talks

10. Jul 2022. ParMOO: a parallel framework for multiobjective simulation optimization problems. *Seventh International Conference on Continuous Optimization (ICCOPT 2022)*, Bethlehem, PA, USA.
9. Dec 2020. Multiobjective optimization of the variability of the high-performance Linpack solver. *2020 Winter Simulation Conference (WSC 2020)*, virtual event.
8. May 2020. Managing computationally expensive blackbox multiobjective optimization problems with libEnsemble. *Spring Simulation Conference (SpringSim '20)*, virtual event.
7. Aug 2019. A surrogate for local optimization using Delaunay triangulations. *Sixth International Conference on Continuous Optimization (ICCOPT 2019)*, Berlin, Germany.
6. Apr 2018. Computing the umbrella neighbourhood of a vertex in the Delaunay triangulation and a single Voronoi cell in arbitrary dimension. *IEEE SoutheastCon 2020*, St. Petersburg, FL, USA.
5. Apr 2018. Nonparametric distribution models for predicting and managing computational performance variability. *IEEE SoutheastCon 2020*, St. Petersburg, FL, USA.
4. Mar 2018. A polynomial time algorithm for multivariate interpolation in arbitrary dimension via the Delaunay triangulation. *ACM Southeast Conference (ACMSE '18)*, Richmond, KY, USA.
3. Apr 2017. Global deterministic and stochastic optimization in a service oriented architecture. *Spring Simulation Conference (SpringSim '17)*, Virginia Beach, VA, USA.
2. Apr 2016. GPU saturation for multiple matrix-vector multiplications. *Virginia Wesleyan College, Undergraduate Research Symposium*, Virginia Beach, VA, USA.
1. Apr 2014. The new Mastermind. *Virginia Wesleyan College, Undergraduate Research Symposium*, Virginia Beach, VA, USA.

Posters and Lightning Talks

10. May 2023. A framework for fully autonomous design of experiments via active learning and multiobjective optimization: challenges and next steps (poster). *11th Intl. Conf. on Learning Representation (ICLR 2023), Workshop on Machine Learning for Materials (ML4Materials)*, Kigali, Rwanda.
9. Oct 2022. ParMOO: a Python library for parallel multiobjective simulation optimization (lightning talk). *FASTMath All-Hands Meeting*, Denver, CO, USA.
8. May 2022. ParMOO: parallel multiobjective optimization in python (poster). *The Argonne, Chicago, Michigan, Northwestern, Toyota, Wisconsin (ACMNTW) Workshop on Optimization and Machine Learning*, Evanston, IL, USA.
7. Nov 2020. Multiobjective optimization of simulations with PARMOO (lightning talk). *Argonne Postdoctoral Research and Career Symposium*, virtual event.
6. Feb 2020. VarSys: managing variability for high performance computers, cloud computing systems, and computer security (poster). *Virginia Tech, Graduate Student Recruitment Weekend, Lab Poster Session*, Blacksburg, VA, USA.
5. Aug 2019. An adaptive weighting scheme for multiobjective optimization (lightning talk). *Argonne National Laboratory, LANS SASSy Seminar Series*, Lemont, IL, USA.
4. Mar 2019. VarSys: managing variability for high performance computers, cloud computing systems, and computer security (poster). *Virginia Tech, Graduate Student Recruitment Weekend, Lab Poster Session*, Blacksburg, VA, USA.
3. Sep 2018. A polynomial time algorithm for multivariate interpolation in arbitrary dimension via the Delaunay triangulation (lightning talk). *Virginia Tech, CS GSC: Lightning Talks*, Blacksburg, VA, USA.
2. Mar 2018. VarSys: managing variability for high performance computers, cloud computing systems, and computer security (poster). *Virginia Tech, Graduate Student Recruitment Weekend, Lab Poster Session*, Blacksburg, VA, USA.
1. Aug 2014. Real-time target identification in Matlab with OpenCV (poster). *US Army Research Laboratories, Summer Student Poster Symposium*, Aberdeen, MD, USA.

Grants

Current

1. Mar 2023 - Sep 2023. **Co-PI** (PI: G. Chen (ANL)), $50K (my share: $25K). *A Scalable Multi-Physics Optimization Framework for Particle Accelerator Design*, institutional award (3 pages + appendices). ANL LDRD: 2023 LDRD Seed (LDRD 2023-0246).

Completed

1. Jun 2019 - Dec 2019. **Primary awardee** (Advisors: J. Larson (ANL) and L. Watson (VT)), $3K/mo stipend. *An Adaptive Weighting Scheme for Multiobjective Optimization*, DOE award for PhD students (3 pages + appendices). DOE SCGSR/ASCR: SCGSR Program 2018 Solicitation 2 (DE-SC0014664).

Advising

Jun 2022 - Aug 2022. Manisha Garg (Urbana-Champaign), NSF MSGI at Argonne
- Project: Model agnostic sampling techniques for generating design-of-experiments

Jun 2022 - Aug 2022. Hyrum Dickinson (Urbana-Champaign), DOE SULI at Argonne
- Project: Visualization tools for the ParMOO library

Teaching

Jan 2022 - Present. **Adjunct Professor: College of DuPage**, Dept. of Computer and Info. Science
- Summer 2023. CIS 2531: Introduction to Python Programming (in-person)
- Spring 2022. CIS 2531: Introduction to Python Programming (online)

Jan 2020 - May 2020. **Instructor of Record: Virginia Tech**, Dept. of Computer Science
- Spring 2020. CS 3114: Data Structures and Algorithms (half in-person, half online)

Jan 2013 - Dec 2015. **Subject Tutor: Virginia Wesleyan University**, Learning Center
- Spring 2013 - Fall 2014. All undergraduate courses in calculus, computer science, and statistics

Professional Services and Activities

Journal Referee

- ACM Transactions on Mathematical Software (2021–Present)
- Quantum Information Processing (2021–Present)
- The Visual Computer Journal (2021)
- MDPI: Mathematical and Computer Applications (2021)
- Journal of Machine Learning Research (2019)

Conference Reviewer

- Int. Congress on Industrial and Applied Mathematics (ICIAM) 2023
- Int. Conf. for HPC, Networking, Storage, and Analysis (Supercomputing) 2021
- IEEE SoutheastCon 2020
- IEEE SoutheastCon 2019
- IEEE SoutheastCon 2018

Minisymposium Organizer

- SIAM Conference on Optimization (2021)
- SIAM Conference on Computational Science and Engineering (2021)

Professional Membership

- ACM (2015–Present)
- SIAM (2016–Present)
- MOS (2022–Present)

Institutional Services

Argonne

Nov 2022 - Present.	**Organizing Committee: FASTMath Institute Seminar Series**
Dec 2022 - Jan 2023.	**Hiring Committee: MCS Division**
Oct 2022 - Dec 2022.	**Technical Reviewer: Sustainable Research Pathways**
Mar 2022 - Apr 2022.	**Red Team Reviewer: ASCR Pre-proposals**

Virginia Tech

Aug 2017 - May 2020.	**Founding Member: Computer Science Graduate Counsel**
Dec 2018 - Mar 2019.	**Lead Student Organizer: Computer Science Graduate Preview Weekend**

Post-Dissertation Courses and Certifications

Jul 2022.	*Distributionally Robust Optimization*, ICCOPT Summer School
Jul 2022.	*Mathematical Optimization in Julia with JuMP*, ICCOPT Summer School
Aug 2020.	*Probability, Geometry, and Computation in High Dimensions Boot Camp*, Simons Institute Workshop
Jul 2020.	*Advanced Python*, LinkedIn Learning

Technical Skills

Languages:	Python, Fortran, C/C++, Java, Matlab
OS:	MacOS, Unix/Linux
Markup:	HTML/CSS, GNU Make, TeX/LaTeX/bibTeX
Libraries:	numpy, pandas, scipy, matplotlib, keras, sklearn, MPI, OpenMP, CUDA, BLAS, LAPACK
Tools/Frameworks:	pytest, sphinx, slurm, CI/CD, GitHub Actions, GitFlow