

# Naifeng Zhang

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**Research Interests:** High-performance code generation targeting CPUs, GPUs, and ASICs; semantics lifting for performance portability and safeguarding AI-generated code.

## EDUCATION

- Ph.D. Electrical and Computer Engineering, Carnegie Mellon University, 2027  
Advisor: Franz Franchetti
- M.S. Electrical and Computer Engineering, Carnegie Mellon University, 2024  
Advisor: Franz Franchetti
- B.S. Computer Science, University of Southern California, 2021  
Advisor: Viktor K. Prasanna  
*Thesis: Lightweight Augmented Neural Network For Performance Prediction and Its Applications*  
*W.V.T. Rusch Undergraduate Engineering Honors Program*
- B.S. Mathematics, University of Southern California, 2021  
*Departmental Honors Program*

## RESEARCH APPOINTMENTS

- 2025 NVIDIA Research  
Intern, Programming Systems and Applications Research Group  
Santa Clara, United States

## AWARDS

- 2024 Best Poster Runner-up  
PRISM Annual Review, Systems & Software track  
*Together with S. Fu (Lead Student) and F. Franchetti*
- 2024 First Place, ACM Student Research Competition  
The International Conference on Parallel Architectures and Compilation Techniques (PACT)  
*Together with S. Fu (Lead Student) and F. Franchetti*
- 2023 Outstanding Short Paper Award  
IEEE High Performance Extreme Computing Conference (HPEC)  
*Together with P. Brinich, A. Ebel, F. Franchetti, and J. Johnson*
- 2023 Second Place, ACM Student Research Competition  
The International Symposium on Code Generation and Optimization (CGO)  
*Together with F. Franchetti*
- 2021 Discovery Scholar Distinction  
University of Southern California
- 2018–21 Academic Achievement Award  
University of Southern California

## FELLOWSHIPS

- 2021–22 Carnegie Institute of Technology Dean’s Fellowship  
2019–21 University of Southern California Provost’s Research Fellowship

## GRANTS

- 2023- *High-Performance Code Generation for Homomorphic Encryption on GPUs using SPIRAL*  
Tuned and benchmarked SPIRAL-generated number theoretic transform (NTT) implementations for homomorphic encryption (HE) applications on state-of-the-art GPUs.  
N. Zhang (PI), F. Franchetti (Co-PI)  
200,000 ACCESS Credits  
NSF

## RESEARCH EXPERIENCE

- 2025- *Durban: Enhancing Performance Portability in HPC Software with Artificial Intelligence*  
Scaled up SPIRAL’s semantics lifting capability via integration with neural code generation.  
DoE
- 2023- *Code Synthesis for the PRISM Architecture*  
Extended SPIRAL to target processing-in-memory (PIM) kernels on PRISM architectures.  
SRC JUMP 2.0
- 2022- *Neocortex: SPIRAL Code Generation for Wafer-Scale Engine*  
Extended SPIRAL to target Cerebras’ second-generation Wafer-Scale Engine (WSE-2).  
NSF
- 2024 *LLM Cerberus: Guarding LLMs against Hallucinating When Generating Mathematical Software*  
Extended SPIRAL with symbolic execution and theorem proving to derive semantics and provide correctness guarantees for large language model (LLM)-generated math kernels.  
NSF
- 2021-23 *Trebuchet: NTTX for OpenFHE*  
Developed the SPIRAL NTTX package to automatically generate high-performance vectorized number theoretic transform (NTT) code for fully homomorphic encryption (FHE) applications.  
DARPA DPRIVE
- 2020–21 *Compiler Abstractions Supporting High Performance on Extreme-scale Resources (CASPER)*  
Developed a compiler-oriented autotuner that automatically profiles a kernel and performs tuning guided by performance prediction.  
DARPA PAPP
- 2019 *Dynamic Data-Aware Reconfiguration, INtegration and Generation (DDARING)*  
Developed a lightweight augmented neural network for performance prediction.  
DARPA SDH

## PUBLICATIONS

### Conference Proceedings

1. **N. Zhang**, S. McAleer, T. Sandholm. “Faster Game Solving via Hyperparameter Schedules.” The AAAI Conference on Artificial Intelligence (AAAI), 2026. *To appear*.
2. Y. Lan, L. Tang, **N. Zhang**, Y. Eum, J. Hoe, F. Franchetti. “A RISC-V Vector Extension for Multi-word Arithmetic.” The International Workshop on RISC-V for HPC (RISCV-HPC), in conjunction with the International Conference for High Performance Computing, Networking, Storage, and Analysis (SC), 2025.
3. **N. Zhang**, S. Fu, F. Franchetti. “Towards Closing the Performance Gap for Cryptographic Kernels Between CPUs and Specialized Hardware” The IEEE/ACM International Symposium on Microarchitecture (MICRO), 2025.
4. Q. Oschatz, **N. Zhang**, M. Franusich, F. Franchetti. “Towards Automated Reasoning Chains for Verification of LLM-Generated Scientific Code.” IEEE High Performance Extreme Computing Conference (HPEC), 2025.
5. **N. Zhang**, F. Franchetti. “Code Generation for Cryptographic Kernels using Multi-word Modular Arithmetic on GPU.” The International Symposium on Code Generation and Optimization (CGO), 2025.
6. **N. Zhang**, A. Ebel, N. Neda, P. Brinich, B. Reynwar, A. G. Schmidt, M. Franusich, J. Johnson, B. Reagen, F. Franchetti. “Generating High-Performance Number Theoretic Transform Implementations for Vector Architectures.” IEEE High Performance Extreme Computing Conference (HPEC), 2023.
7. D. Sun, **N. Zhang**, F. Franchetti. “Optimization and Performance Analysis of Shor’s Algorithm in Qiskit.” IEEE High Performance Extreme Computing Conference (HPEC), 2023.
8. D. Soni, N. Neda, **N. Zhang**, B. Reynwar, H. Gamil, B. Heyman, M. N. T. Moopan, A. Al Badawi, Y. Polyakov, K. Canida, M. Pedram, M. Maniatakos, D. B. Cousins, F. Franchetti, M. French, A. Schmidt, B. Reagen. “RPU: The Ring Processing Unit.” IEEE International Symposium on Performance Analysis of Systems and Software (ISPASS), 2023.
9. **N. Zhang**, A. Srivastava, R. Kannan, V. K. Prasanna. “GenMAT: A General-Purpose Machine Learning-Driven Auto-Tuner for Heterogeneous Platforms.” The Workshop on Programming Environments for Heterogeneous Computing (PEHC), in conjunction with the International Conference for High Performance Computing, Networking, Storage, and Analysis (SC), 2021.
10. A. Srivastava\*, **N. Zhang**\*, R. Kannan, V. K. Prasanna. “Towards High Performance, Portability, and Productivity: Lightweight Augmented Neural Networks for Performance Prediction.” The International Conference on High Performance Computing, Data, and Analytics (HiPC), 2020. *\*Equal contribution*.
11. C. Imes, A. Colin, **N. Zhang**, A. Srivastava, V. K. Prasanna, J. P. Walters. “Compiler Abstractions and Runtime for Extreme-scale SAR and CFD Workloads.” The Workshop on Extreme Scale Programming Models and Middleware (ESPM2), in conjunction with the International Conference for High Performance Computing, Networking, Storage, and Analysis (SC), 2020.

### Other Conference Papers, Technical Reports, Extended Abstracts, and Posters

1. **N. Zhang**, S. Rao, M. Franusich, F. Franchetti. “Towards Semantics Lifting for Scientific Computing: A Case Study on FFT.” The Theory and Practice of Static Analysis Workshop (TPSA), in conjunction with the ACM SIGPLAN Symposium on Principles of Programming Languages (POPL), 2025, Extended abstract with presentation.
2. S. Fu, **N. Zhang**, F. Franchetti. “Accelerating High-Precision Number Theoretic Transforms using Intel AVX-512.” The International Conference on Parallel Architectures and Compilation Techniques (PACT), 2024, Extended abstract with poster and presentation. **First Place, ACM Student Research Competition. Best Poster Runner-up** at PRISM Annual Review, Systems & Software track.

3. Y. Eum, **N. Zhang**, L. Tang, F. Franchetti. “Towards a RISC-V Instruction Set Extension for Multi-word Arithmetic.” IEEE High Performance Extreme Computing Conference (HPEC), 2024, Extended abstract with poster.
4. P. Brinich, **N. Zhang**, A. Ebel, F. Franchetti, J. Johnson. “Twiddle Factor Generation for a Vectorized Number Theoretic Transform.” IEEE High Performance Extreme Computing Conference (HPEC), 2023, Extended abstract with poster. **Outstanding Short Paper Award.**
5. H. Mankad, A. Rovinelli, M. Zecevic, P. McCorquodale, F. Franchetti, **N. Zhang**, S. Rao, R. A. Lebensohn, L. Capolungo. “EVPFFTX: A First Look at FFTX Applications in Material Science.” IEEE High Performance Extreme Computing Conference (HPEC), 2023, Extended abstract with poster.
6. D. B. Cousins, Y. Polyakov, A. Al Badawi, M. French, A. Schmidt, A. Jacob, B. Reynwar, K. Canida, A. Jaiswal, C. Mathew, H. Gamil, N. Neda, D. Soni, M. Maniatakos, B. Reagen, **N. Zhang**, F. Franchetti, P. Brinich, J. Johnson, P. Broderick, M. Franusich, B. Zhang, Z. Cheng, M. Pedram. “TREBUCHET: Fully Homomorphic Encryption Accelerator for Deep Computation.” The Government Microcircuit Applications and Critical Technology Conference (GOMACTech), 2023, Preprint with presentation.
7. **N. Zhang**, F. Franchetti. “Generating Number Theoretic Transforms for Multi-Word Integer Data Types.” The International Symposium on Code Generation and Optimization (CGO), 2023, Extended abstract with poster and presentation. **Second Place, ACM Student Research Competition.**
8. **N. Zhang**, H. Gamil, P. Brinich, B. Reynwar, A. Al Badawi, N. Neda, D. Soni, K. Canida, Y. Polyakov, P. Broderick, M. Maniatakos, A. G. Schmidt, M. Franusich, J. Johnson, B. Reagen, D. B. Cousins, F. Franchetti. “Towards Full-Stack Acceleration for Fully Homomorphic Encryption.” IEEE High Performance Extreme Computing Conference (HPEC), 2022, Extended abstract with presentation.
9. I. Grosz, **N. Zhang**, M. Heule. “Towards the shortest DRAT proof of the Pigeonhole Principle.” The Pragmatics of SAT Workshop (PoS), in conjunction with the International Conference on Theory and Applications of Satisfiability Testing (SAT), 2022, Preprint with presentation.

## TALKS

### Seminars

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|------|--|
| 2025 | <i>Towards Closing the Performance Gap for Cryptographic Kernels Between CPUs and Specialized Hardware</i><br>Computer Architecture Lab at Carnegie Mellon (CALCM), Oct. 2<br>Carnegie Mellon University, United States  |
| 2025 | <i>Code Generation for Cryptographic Kernels using Multi-word Modular Arithmetic</i><br>Ming Hsieh Department of Electrical and Computer Engineering, May 9<br>University of Southern California, United States          |
| 2025 | <i>Code Generation for Cryptographic Kernels using Multi-word Modular Arithmetic</i><br>Department of Electrical and Computer Engineering, May 2<br>New York University, United States                                   |
| 2025 | <i>Optimization and Performance Analysis of Shor’s Algorithm in Qiskit and Beyond</i><br>The Center for Quantum Computing and Information Technologies (QCiT), Apr. 1<br>Carnegie Mellon University, United States       |
| 2025 | <i>Code Generation for Cryptographic Kernels using Multi-word Modular Arithmetic</i><br>The Programming Languages Group at the University of Pennsylvania (PLClub), Feb. 21<br>University of Pennsylvania, United States |

- 2025 *Code Generation for Cryptographic Kernels using Multi-word Modular Arithmetic*  
Computer Architecture Lab at Carnegie Mellon (CALCM), Feb. 14  
Carnegie Mellon University, United States

### Guest Lectures

- 2025 *Code Generation for Cryptographic Kernels using Multi-word Modular Arithmetic*  
Computational Problem Solving for Engineers, Apr. 1  
Carnegie Mellon University, United States

### Conference and Workshop Presentations

- 2025 *Towards Closing the Performance Gap for Cryptographic Kernels Between CPUs and Specialized Hardware*  
The IEEE/ACM International Symposium on Microarchitecture (MICRO), Oct. 22  
Virtual
- 2025 *Code Generation for Cryptographic Kernels using Multi-word Modular Arithmetic*  
The Workshop on Architectures for Zero-Knowledge Proofs and Verifiable Computation (ZKARCH), in conjunction with the IEEE/ACM International Symposium on Microarchitecture (MICRO), Oct. 18  
Virtual
- 2025 *Towards Semantics Lifting for Scientific Computing: A Case Study on FFT*  
Oak Ridge National Laboratory AI4Science Workshop, Apr. 30  
Oak Ridge, United States
- 2025 *Code Generation for Cryptographic Kernels using Multi-word Modular Arithmetic on GPU*  
The International Symposium on Code Generation and Optimization (CGO), Mar. 4  
Las Vegas, United States
- 2025 *Towards Semantics Lifting for Scientific Computing: A Case Study on FFT*  
The Theory and Practice of Static Analysis Workshop (TPSA), in conjunction with the ACM SIGPLAN Symposium on Principles of Programming Languages (POPL), Jan. 21  
Denver, United States
- 2023 *Generating High-Performance Number Theoretic Transform Implementations for Vector Architectures*  
IEEE High Performance Extreme Computing Conference (HPEC), Sep. 29  
Virtual
- 2023 *Generating Number Theoretic Transforms for Multi-Word Integer Data Types*  
The International Symposium on Code Generation and Optimization (CGO), Feb. 28  
Montreal, Canada
- 2022 *Towards Full-Stack Acceleration for Fully Homomorphic Encryption*  
IEEE High Performance Extreme Computing Conference (HPEC), Sep. 23  
Virtual
- 2021 *GenMAT: A General-Purpose Machine Learning-Driven Auto-Tuner for Heterogeneous Platforms*  
The Workshop on Programming Environments for Heterogeneous Computing (PEHC), in conjunction with the International Conference for High Performance Computing, Networking, Storage, and Analysis (SC), Nov. 19  
Virtual
- 2020 *Towards High Performance, Portability, and Productivity: Lightweight Augmented Neural Networks for Performance Prediction*  
The International Conference on High Performance Computing, Data, and Analytics (HiPC), Dec. 16  
Virtual

## Tutorials

- 2026 *SPIRAL: Pre-Silicon and Early-Prototype Performance Estimation Using Highly Optimized Code*  
ACM International Conference on Architectural Support for Programming Languages and Operating Systems (ASPLOS), *To appear*  
Together with F. Franchetti  
Pittsburgh, United States
- 2025 *Open Source SPIRAL 8.5.1 Tutorial*  
IEEE High Performance Extreme Computing Conference (HPEC), Sep. 17  
Together with F. Franchetti and M. Franusich  
Virtual
- 2024 *Open Source SPIRAL 8.5 Tutorial*  
IEEE High Performance Extreme Computing Conference (HPEC), Sep. 25  
Together with F. Franchetti and M. Franusich  
Virtual
- 2023 *Open Source SPIRAL 8.5 Tutorial*  
IEEE High Performance Extreme Computing Conference (HPEC), Sep. 27  
Together with F. Franchetti, M. Franusich, and P. Broderick  
Virtual

## TEACHING EXPERIENCE

### Carnegie Mellon University

#### *Teaching Assistant*

- 24 Fall Mathematical Foundations of Electrical Engineering  
23 Spring Computational Problem Solving for Engineers

### University of Southern California

#### *Undergraduate Teaching Assistant*

- 21 Spring Special Topics - Accelerated Computing Using FPGAs  
20 Fall Parallel and Distributed Computation  
20 Spring Special Topics - Accelerated Computing Using FPGAs  
20 Spring Discrete Methods in Computer Science  
19 Fall Parallel and Distributed Computation  
19 Fall Discrete Methods in Computer Science

## MENTORING

### Undergraduate

2024- Misho Alexandrov  
2024- Sophia Fu  
2023- Gordon Xu  
2024 Govind Malasani  
2025 Yiwen Jiang  
2024 Zubin Narayan  
2024 Youngjin Eum  
2024 Steven Lee  
2022-23 Matt Ngaw  
2022-23 Jimmy Zhou

### Master's

2025- Yunhao Lan  
2024-25 Yujun Lee  
2023 Kofi Poku  
2022-23 Dewang Sun  
2022 Hongbo Sun

## SERVICE

### Conference Program Committees

The AAAI Conference on Artificial Intelligence (AAAI), 2026

The Workshop on AI Assisted Software Development for HPC (AI4Dev), in conjunction with the International Conference on Parallel Processing (ICPP), 2025

### Journal Peer Review

IEEE Transactions on Dependable and Secure Computing (TDSC)

IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (TCAD)

IEEE Transactions on Computational Social Systems (TCSS)

IEEE Transactions on Mobile Computing (TMC)

IEEE Transactions on Emerging Topics in Computing (TETC)

ACM Computing Surveys (CSUR)

The International Journal of High Performance Computing Applications (IJHPCA)

IEEE Transactions on Parallel and Distributed Systems (TPDS)

IEEE Transactions on Information Forensics & Security (T-IFS)

### Service to the University

Carnegie Institute of Technology College Council, 2025-26

CMU Electrical and Computer Engineering Faculty Hiring Student Council, 2022-25

### Outreach

CMU College of Engineering Graduate Student Outreach Committee, 2023

Updated December 2025