**Education**

**Princeton University**, Princeton, NJ  
*Ph.D. in Computer Science*  
*M.A. in Computer Science, est. 2024*  
Advisor: Prof. Aarti Gupta  
Fields of study: Compilers; Formal Verification; Distributed Systems; Equality Saturation

**University of Washington**, Seattle, WA  
*B.S. in Computer Science, GPA: 3.89/4.0 (Cum Laude)*  
Advisors: Prof. Zachary Tatlock & Dr. Steven Lyubomirsky  
Selected Honor: CRA Outstanding Undergraduate Researcher Award, Honorable Mention (2022)

**Research**

**CATSTAIL: Synthesizing Packet Programs via Equality Saturation**  
June. 2023 – Now  
TL;DR CATSTAIL is an equality saturation-based P4 program synthesizer. Previous works use SKETCH to synthesize the program, which takes too long to make debugging on actual hardware possible. Compared with SKETCH, CATSTAIL is up to 30x/2000x faster (preliminary) in finding the optimal stage allocation for Intel Tofino/Domino (Banzai ALU). I lead the design and implementation of CATSTAIL.

**Verifying correctness of SW/HW mappings**  
June. 2023 – Now  
TL;DR hex is a language for accelerator operation explication and a tool for verifying the software-hardware mapping correctness. My contributions and work in progress are
- Implemented a case study for FlexASR pooling instructions in hex and verified its correctness against the software implementations.  
- Designing memory layout mapping invariant inference/generation algorithm.

**Improving Term Extraction with Acyclic Constraints**  
Sep. 2022 – Feb. 2023  
TL;DR To have a better term extraction algorithm for egg, an equality saturation framework, we devise the encoding using Weighted partial MaxSAT and include a set of Acyclic constraints that ensures the acyclicity of the extracted term. Our encoding demonstrates better solver time (~3x speed up) for the case study of extracting tensor programs. I led the development of the case study and the encoding, and authored the workshop paper at PLDI EGRAPHS’23.

**Pyrope: Towards Correct-by-construction Hardware Modeling**  
Mar. 2022 – June. 2022  
TL;DR Pyrope is a Python-based framework for high-level hardware modeling. Pyrope enables expressing proofs and guarantees of modeled instruction in Python and transpiles hardware models into Dafny for verification. I led the development of Pyrope during my internship at Intel Labs.

**3LA: Application-level Validation of Accelerator Designs**  
June. 2021 – June. 2022  
TL;DR 3LA is a software/hardware co-verification methodology for DL accelerators that aids hardware developers in performing early-stage application-level debugging. My contributions are
- Led the development of flexmatch and extended Glenside to support a more diverse set of models.  
- Implemented the compilation pipeline for VTA using BYOC interfaces of TVM.  
- Implemented handwritten digit recognition (on CIFAR) and image classification (on ImageNet) for VTA. Passed the mapping validation using 3LA.  
- Co-authored a ASPLOS LATTE’21 workshop paper.  
- Co-authored a paper under review at ACM TODAES.
Dynamic Tensor Rematerialization

TL;DR Dynamic Tensor Materialization (DTR) is an online, heuristic-based checkpointing algorithm that enables DL inference under constrained memory budgets. My contributions are:

- Identified problems in the PyTorch DTR implementation.
- Designed the evaluation framework for DTR and extended the case studies to multiple new DL applications (e.g. Unrolled GAN, UNet).
- Co-authored the paper published at ICLR’21.

Publications

- Mike He, Haichen Dong, Sharad Malik, and Aarti Gupta. Improving Term Extraction with Acyclic Constraints, 2023 [Paper]
- [submitted to ACM TODAES] Bo-Yuan Huang*, Steven Lyubomirsky*, Yi Li, Mike He, Thierry Tambe, Gus Henry Smith, Akash Gaonkar, Vishal Canumalla, Gu-Yeon Wei, Aarti Gupta, Sharad Malik, and Zachary Tatlock. Application-Level Validation of Accelerator Designs Using a Formal Software/Hardware Interface, 2022 [Pre-print]
- Bo-Yuan Huang*, Steven Lyubomirsky*, Thierry Tambe*, Yi Li, Mike He, Gus Smith, Gu-Yeon Wei, Aarti Gupta, Sharad Malik, and Zachary Tatlock. From DSLs to Accelerator-rich Platform Implementations: Addressing the Mapping Gap, 2021 [Paper]
- Marisa Kirisame*, Steven Lyubomirsky*, Altan Haan*, Jennifer Brennan, Mike He, Jared Roesch, Tianqi Chen, and Zachary Tatlock. Dynamic Tensor Rematerialization, 2021 [ArXiv]

Service

- AEC member of POPL’24, MLSys’23, MICRO’21
- Mentor of the Ph.D. application mentoring program (Princeton, 2023)

Internships

Taichi Graphics, Remote and Beijing, China

Compiler R&D Intern (C++/Python)

- Refactored the intermediate representation (IR) of Taichi Language
- Implemented standalone Tensor type for better compilation speed
- Adapted compiler passes (e.g. Load/Store forwarding, Dead code elimination, reaching definition, etc.) to optimize for tensor type expressions
- Implemented LLVM-based code generation for tensor type for Superword-level vectorization

Intel Labs, Hillsboro, OR

Formal Verification Research Intern (Formal Methods/Python/Dafny)

Developed the Pyrope framework for correct-by-construction hardware modeling.

- Facilitated correct-by-construction hardware modeling purely in Python
- Encoded the correctness proof of (multi-)montgomery reduction algorithm in Python and verified successfully by compiling to Dafny
- Unified “sources of truth” for correctness proofs and programming model implementations

UWPLSE, Seattle, WA

Research Assistant (PL/Compiler)

Responsible for conducting research with Prof. Zachary Tatlock, specifically,

- Implemented evaluations in the Dynamic Tensor Rematerialization project
- Designed a flexible matching algorithm for domain-specific language compilers.
- Led research projects with other undergraduate students
- Attended and presented at reading groups
Selected Projects & Contributions

**CatsTail**: Synthesizing Packet Programs via Equality Saturation (Rust) GitHub

**Music Scores**: Reverse engineering of some arrangements (Lilypond) GitHub

**flexmatch**: Flexible offload pattern matching for DNNs (Python, Rust) GitHub

**egg-taichi**: Towards automated super-optimization for Taichi programs (Rust) GitHub

**taichi**: High-performance parallel computing in Python (C++, Python) GitHub

**Glenside**: Term rewriting for tensor programs (Rust) GitHub

**veripy**: auto-active verification for Python programs (Python) GitHub

**dtlc**: Dependently-typed lambda calculus (OCaml) GitHub

**Sager**: A demonic graph synthesizer for worst-case performance (Rosette, Racket) GitHub

**Ruxl**: Applicatives, Monads and a “Future” for Rust (Rust) GitHub

**Lambda Calculus**: UTLC, STLC and System F in OCaml (OCaml) GitHub

**SimGE**: DTR for memory movement optimization (Rust) GitHub

**Multi-Paxos**: Implementation of Multi-Paxos in Java (Java) CSE 452

**ETH Client**: Implementation of an ETH-like Blockchain (Rust) COS 471

More on my GitHub ⋆ : Contributor

Teaching

- **COS 516**: Automated Reasoning about Software (TA, Princeton University)
- **CSE 505**: Principles of Programming Languages (TA, University of Washington)

Skills

- **Languages**: C/C++, Python, Rust, OCaml, Coq, Dafny, etc. (Open to other languages)
- **Compiler & Applied PL**: Equality Saturation, Static Analysis, Computer-aided Reasoning, SMT
- **PL Theory**: Formal Verification, Type Theory, Mathematical Logic
- **Systems**: Distributed Systems, Machine Learning Systems, Data Center Systems
- **Others**: Algorithms and Data Structures
- **Fun Fact**: I am more seasoned in playing the violin than coding ⚫; I have:
  1. a Lv.9 certificate* (similar to ABRSM Grade 8) issued by Central Conservative of Music;
  2. > 20-year violin solo experience;
  3. Multiple 1st Prizes (various local competitions in Beijing) and a Silver medal (Beijing regional)†;
  4. 6-year experience with symphony orchestras; 3-year experience as the 2nd Principal Violinist;
  5. 3-year experience with a piano quartet/quintet and multiple string quartets (with 1 CD made);
  6. ~ 4 public concerts with a philharmonic orchestra* at The Giant Egg, Beijing, China.

* : The highest level for non-professionals
† : Awarded during middle and high school years.
★ : The Beijing National Day School Philharmonic Orchestra