Zishen Wan

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EDUCATION

Georgia Institute of Technology Atlanta, GA
Ph.D., School of Electrical and Computer Engineering (ECE) 2024 (expected)
- Advisor: Prof. Arijit Raychowdhury
- Research Areas: VLSI, computer architecture, deep learning, robotics
- GPA: 4.00/4

Harvard University Cambridge, MA
M.S., School of Engineering and Applied Science (SEAS) 2020
- Advisor: Prof. Vijay Janapa Reddi, Prof. David Brooks
- Research Areas: VLSI, computer architecture, deep learning, robotics
- GPA: 3.95/4 (Selected Courses: Computer Architecture, Edge Computing, Decision Theory, Computer Vision)
- Courses-registration at EECS Department, **Massachusetts Institute of Technology** (Machine Learning, VLSI, DL Hardware)

Harbin Institute of Technology (HIT) Harbin, China
B.E. with High Honors, Department of Electrical Engineering (EE) 2018
- Overall GPA: 93.5/100 (3.95/4); Major GPA: 95.9/100 (4.00/4); Rank: 2/230 (top 1%)
- Exchange student at **National Tsing-Hua University** and **National Chiao-Tung University** in 2017, GPA 4.27/4.3

PUBLICATIONS

Conference

- **Zishen Wan**, Aqeel Anwar, Yu-Shun Hsiao, Tianyu Jia, Vijay Janapa Reddi, Arijit Raychowdhury. "Analyzing and Improving Fault Tolerance of Learning-Based Navigation System", under review in *ACM/EDAC/IEEE Design Automation Conference (**DAC**), 2021.*
- Yu-Shun Hsiao*, **Zishen Wan***, Tianyu Jia, Radhika Ghosal, Arijit Raychowdhury, David Brooks, Gu-Yeon Wei, Vijay Janapa Reddi. "MAVFI: Micro Aerial Vehicle Fault Injection with End-to-End Anomaly Detection and Recovery", under review in *IEEE/IFIP International Conference on Dependable Systems and Networks (**DSN**), 2021.* **(*Equal Contributions, listed in alphabetical order)**
- Srivatsan Krishnan, **Zishen Wan**, Kshitij Bhardwaj, Paul Whatamough, Aleksandra Faust, Sabrina M. Neuman, Gu-Yeon Wei, David Brooks, Vijay Janapa Reddi. "Algorithm-Hardware Co-Design for Aerial Robots", under review in *IEEE/ACM International Symposium on Computer Architecture (**ISCA**), 2021.*
- Max Lam*, Sharad Chitlangia*, Srivatsan Krishnan*, **Zishen Wan**, Aleksandra Faust, Gabriel Barth-Maron, Vijay Janapa Reddi. "QuaRL: Quantized Reinforcement Learning", under review in *4th Conference on Machine Learning and System (**MLSys**), 2021.*
- Thierry Tambe, En-yu Yang, **Zishen Wan**, Yuntian Deng, Vijay Janapa Reddi, Alexander Rush, David Brooks, Gu-Yeon Wei. "Algorithm-Hardware Co-Design of Adaptive Floating-Point Encodings for Resilient Deep Learning Inference," In *Design Automation Conference (**DAC**), 2020.* **(Best Paper Award)** [pdf]
- Srivatsan Krishnan*, Sharad Chitlangia*, Max Lam*, **Zishen Wan**, Aleksandra Faust, Vijay Janapa Reddi. "Quantized Reinforcement Learning (QuaRL)", In *3rd Conference on Machine Learning and System (**MLSys**) Workshop, 2020.* [pdf]

Journal

- **Zishen Wan**, Bo Yu, Thomas Yuang Li, Jie Tang, Yuhao Zhu, Yu Wang, Arijiti Raychowdhury, Shaoshan Liu. "Robotic Computing on FPGA", To appear in *IEEE Circuits and Systems Magazine (**CAS-M**), 2021.* [pdf]
- Srivatsan Krishnan, **Zishen Wan**, Kshitij Bhardwaj, Paul Whatamough, Aleksandra Faust, Gu-Yeon Wei, David Brooks, Vijay Janapa Reddi. "The Sky is Not the Limit: A Visual Performance Model for Cyber-Physical Co-design in Aerial Autonomous Machines", In *IEEE Computer Architecture Letters (**CAL**), Mar 2020, vol. 19, issue. 1, pp. 38-42.* **(Best Paper Award)** [pdf]

- Peng Xie, Yu Wen, **Zishen Wan**, Yishan Wang. "Influences of Group Velocity Dispersion on Ultrafast Pulse Shaping in Time Lens," In *Physica Scripta, 94(12):125503, 2019* [pdf]
- Peng Xie, Yu Wen, Wenqiang Yang, **Zishen Wan**, Jiarui Liu, Xinyu Wang, Siqi Da, Yishan Wang. "Tunable Gallium Nitride-based Devices for Ultrafast Signal Processing," In *Modern Physics Letter B, 33(17):1950187, 2019* [pdf]
- Weiwei Li, Xueguang Zhang, **Zishen Wan**, Yini Zhao, Dianguo Xu. "Simplified Algorithm for Non-orthogonal Coordinate System SVM of Three-level Converter Considering Optimal Switching Sequence," In *Transactions of China Electrotechnical Society, 34(zk1): 181-188, 2019* [pdf]
- Peng Xie, Yu Wen, **Zishen Wan**, Xinyu Wang, Jiarui Liu, Wenqiang Yang, Xiaofeng Li, Yishan Wang. "Electrically Tunable Temporal Imaging in a Graphene-based Waveguide," In *Japanese Journal of Applied Physics, 58(5):050914, 2019* [pdf]

Undergraduate Thesis

- **Zishen Wan**. "Modulation and Neutral Voltage Balance Control of NPC Three-level Converter (**Best Undergraduate Thesis Award** of Harbin Institute of Technology)," In *Proceedings of HIT Best Undergraduate Thesis, 2018* [pdf]

RESEARCH EXPERIENCE

Georgia Institute of Technology –Integrated Circuits and Systems Research Lab Atlanta, GA

Role: Graduate Research Assistant Aug.2020-Present

Advisor: Prof. Arijit Raychowdhury

Project: Analysis and Improvement the Fault Tolerance of Learning-Based Navigation System

- Characterizing and evaluating the resilience of reinforcement learning-based navigation systems, with respect to various types of algorithms, fault models and datatypes, from both training and inference phases.
- Proposing efficient fault mitigation techniques to detect and recover faults effects and improve the fault tolerance of reinforcement learning-based navigation systems.

Project: Energy-efficient and Reliable Hardware Accelerator for Autonomous Systems and Edge Intelligence [CAS2021]

- Designing specialized hardware (ASIC, FPGA) to accelerate critical computational-intensive kernels in robotic perception, localization and motion planning.

Harvard University – Edge Computing Lab Cambridge, MA

Role: Graduate Research Assistant Jan.2019-Aug.2020

Advisor: Prof. Vijay Janapa Reddi

Project: Micro Aerial Vehicle (MAV) Fault Injection and with End-to-End Anomaly Detection and Recovery

- Proposed a reliability analysis methodology (MAVFI tool) to study the resilience of MAV applications, and performed extensive fault tolerance characterization in the end-to-end MAV compute pipeline.
- Proposed two online anomaly fault detection and recovery schemes with statistical model and autoencoder. Demonstrated that the proposed schemes can greatly improve MAV quality-of-flight and reliability with insignificant compute overhead.

Project: Agile System Design Flow for End-to-End (E2E) Learning-Based Aerial Autonomous Machine [CAL2020]

- Proposed a framework to automate algorithm-SoC co-design for aerial robots. Built a systolic array-based simulator to conduct SoC-level design space exploration. Implemented ML (Bayesian Optimization/Reinforcement Learning) methods to automate DSE. Explored architectural optimizations like per-layer DVFS and Non-Volatile Memory technologies.
- Used the Catapult HLS tool to generate Verilog RTL from SystemC/C++ source code, and evaluated the PPA results of E2E models for robot tasks. Run the ASIC flow of place-and-route and generated a layout of the floor-planed accelerator.
- Proposed a roofline model to determine the role of compute on the efficiency of aerial robots. Characterized E2E models on Nvidia Xavier, TX2, Intel NCS, RasPi and Google Coral. Applied analytical models to streamline the DSE of accelerators.

Project: Comprehensive Quantization Study on Reinforcement Learning [MLSys2020]

- Conducted the first comprehensive study that quantifies the effects of quantization on various deep reinforcement learning policies. Applied post-training quantization and quantization-aware-training to a spectrum of reinforcement learning tasks and training algorithms (PPO, A2C, DDPG, and DQN). Deployed a quantized RL based navigation policy to RasPi-3b.

Harvard University – VLSI and Architecture Lab Cambridge, MA

Role: Graduate Researcher Jan.2019-Jul.2020
Advisor: Prof. David Brooks, Prof. Gu-Yeon Wei
Project: Algorithm-Hardware Co-design of Various Datatypes for Resilient Deep Learning Inference [DAC2020]

- Implemented AdaptivFloat, a numeric for resilient deep learning inference. Performed quantization experiments on integer, AdaptivFloat, block FP, float point and posit encodings across a diverse set of CNN, RNN and Transformer models with Pytorch. AdaptivFloat demonstrates much greater resiliency at low precision and higher energy efficiency.

Massachusetts Institute of Technology Cambridge, MA
Role: Graduate Researcher Aug.2018-Dec.2018
Advisor: Dr. Peng Xie
Project: Design Analysis Algorithms and Simulation Models for Nano-Scale Systems [MPL2019, PS2019, JJAP2019]

- Implemented system algorithms for analyzing light and matter interactions based on Runge Kutta method. Built simulation models for nano-scale device design, group velocity dispersion, third-order dispersion based on the finite element method.

Harbin Institute of Technology – Power Electronics Lab Harbin, China
Role: Undergraduate Research Assistant Dec.2016-Jun.2018
Advisor: Prof. Xueguang Zhang, Prof. Dianguo Xu
Project: Modulation and Optimal Control Strategy for Multi-Level Converter [Thesis2018, TCES2019]

- Proposed a neutral voltage balance control method and a simplified optimal switching sequences method for nonorthogonal space vector modulation of three-level converter. Established mathematical and simulation models in MATLAB. Built a DSP-based multi-level grid-connected experimental platform and verified the feasibility of the proposed methods.

SELECTED COURSE PROJECTS

Computer Architecture / VLSI Field:

Project 1: Image Pre-processor for Robust DNN Resistant to Adversarial Attacks (Best Project Award)
***Instructor**: Prof. Vivienne Sze. **Course:** Design and Analysis of Digital Integrated Circuits (MIT)* Sep.2018-Dec.2018

- Proposed and designed an image pre-processor with three different image filtering algorithms for robust DNN resistant to adversarial attacks. Performed RTL synthesis, layout, place and route using Cadence 90nm technology.
- Exploited various optimization methods to reduce computation and increase throughputs, such as data reuse, parallelism and approximations. Explored various trade-offs in designing with voltage scaling analysis and different architecture comparisons.

Project 2: AutoX: Automating Algorithm-SoC Co-design for Aerial Robots (Best Project Award)
***Instructor**: Prof. Vijay Janapa Reddi. **Course:** Edge Computing: Autonomous Machines (Harvard)* Sept.2019-Dec.2019

- Proposed an agile HW-SW co-design flow for aerial robots. The front-end is to design and validate end-to-end models for robot tasks, and the back-end is to synthesize hardware accelerators for processing the model efficiently based on the SystemC +HLS approach and C++-to-RTL flow. The PPA results are measured on post-HLS Verilog RTL using 16nm technology.

Project 3: Study of Posit Numeric in Speech Recognition Neural Inference Sep.2018-Dec.2018
***Instructor**: Prof. David Brooks. **Course:** Advanced Topics in Computer Architecture (Harvard)*

- Studied the impact of various precisions and datatypes on speech-to-text neural inference. Implemented Python and C++ modules for Posit numeric operations and converting in all directions among float, fixed-point and Posit.
- Implemented SystemVerilog adder and multiplier modules for floating-point, fixed-point and Posit. Performed RTL synthesis, layout, place and route to compare the hardware power, performance and area results for different encodings.

Project 4: MIPS Processor Implementation and Software Optimization of Matrix Multiplication Jan.2019-May.2019
***Instructor**: Prof. David Brooks. **Course**: Advanced Computer Architecture (Harvard).*

- Implemented a MIPS processor using SystemVerilog, C and Python, along with Xilinx FPGA implementations.
- Performed and examined TopDown analysis on linear algebra operations as implemented in Eigen and OpenBLAS libraries. Explored software optimization of matrix multiplication, such as tiling, reduced precision, sparsity, quantization, etc.

Deep Learning / Machine Learning Field:

Project 1: Generative Model for Human Pose Transferring Between Videos (Full Score Project) Sept.2018-Dec.2018

***Instructor**: Prof. Devavrat Shah, Prof. Suvrit Sra, Prof. David Sontag. **Course**: Machine Learning (MIT).*

- Performed a human pose transfer using the generative model, video-to-video synthesis, Openpose and Densepose. Utilized a coarse-to-fine training process and achieved 10% performance improvement shown by Intersection Over Union.
- Proposed a face transfer method from ground truth to generated image, solving the problem of detail loss in generated face.

Project 2: Research on the Reliability of Autonomous Vehicles Jan.2019-May.2019

***Instructor**: Prof. Vijay Janapa Reddi. **Course**: Special Topics in Computer Science (Harvard).*

- Researched on the fault tolerance of perception system, compute system and control system of micro aerial vehicles, based on MAVBench, a framework for autonomous aerial vehicles. Explored the role of compute in autonomous vehicles.
- Performed hundreds of experiments using Unreal Engine, AirSim as environment simulator, Nvidia Jetson Xavier and TX2 as companion computer, under Robot Operating System (ROS).

Project 3: Wikipedia Web Traffic Time Series Forecasting Jan.2019-May.2019

***Instructor**: Prof. Demba Ba. **Course**: Decision Theory (Harvard).*

- Implemented Prophet, ARIMA, Encoder-decoder, GRU, LSTM, XGBoost, Kalman Filter and MCMC algorithms on approximately 145,000 Wikipedia articles to address the forecasting web traffic problem.

AWARDS

- Best Paper Award in IEEE Computer Architecture Letter (CAL) Dec.2020
- Best Paper Award in ACM/EDAC/IEEE Design Autonomation Conference (DAC) Jul.2020
- Dean's Fellowship, Purdue University (2 of over 1600 applicants) (declined) Feb.2020
- Best Undergraduate Thesis Award of HIT (Top 1%) Jun.2018
- Top Ten Outstanding Graduates at HIT (Top 1%) Jun.2018
- Merit Student of Heilongjiang Province (Top 0.1%), Merit Student of Hebei Province (Top 0.1%) Apr.2016
- Second Prize (Team leader), The 11th Undergraduate Academic Forum of HIT Aug.2017
- First Prize (Team leader), National Undergraduate Mathematical Contest in Modeling, China Sept.2016
- Honorable Mention (Team leader), America MCM/ICM Competition Feb.2016/2017

SCHOLARSHIPS

- Chiang Chen Overseas Graduate Scholarship (10 of all undergraduates and graduates in China, $50,000/person) Jun.2018
- China Telecom Scholarship (5 of all undergraduates and graduates in HIT) May.2018
- First Class of *Chunhui* Innovation Achievement Award (3 of all undergraduates in HIT, Highest Honor of HIT) Apr.2018
- Innovation and Entrepreneurship Scholarship, Ministry of Industry and Information, China Nov.2017
- First Class Academic Excellence Scholarship for Freshman & Sophomore & Junior, HIT (Top 3%) Oct.2015/2016/2017
- Siemens Academic Scholarship (30 of all undergraduates and graduates in HIT) Oct.2016
- Johnson Electric Academic Scholarship (15 of all undergraduates and graduates in HIT) Oct.2015

SKILLS

- **Software & Hardware Language:** Python, C/C++, Verilog HDL, SystemC, MATLAB, SQL, LATEX, MIPS assembly
- **Tools:** Catapult, HSPICE, Xilinx FPGA, Cadence, Quartus, OrCAD, MultiSim, Proteus, Altium Designer, Unreal, AirSim
- **Machine Learning Framework:** Pytorch, TensorFlow, Keras, Caffe, Scikit-learn