Zishen Wan

Georgia Institute of Technology | Room 1618, 808 Marietta St NW, Atlanta, GA 30318
+1 (857) 999-6367 | zishenwan@gatech.edu | https://zishenwan.github.io

EDUCATION

Georgia Institute of Technology Atlanta, GA
Ph.D., School of Electrical and Computer Engineering (ECE) 2020-2024 (expected)
- Advisor: Prof. Arijit Raychowdhury
- Research Areas: VLSI, computer architecture, edge intelligence
- GPA: 4.00/4

Harvard University Cambridge, MA
M.S., School of Engineering and Applied Science (SEAS) 2018-2020
- Advisor: Prof. Vijay Janapa Reddi
- Research Areas: computer architecture, VLSI, robotics
- GPA: 3.95/4
- 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) 2014-2018
- 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

(* Indicates Equal Contributions)

Book

[B1] Shaoshan Liu, **Zishen Wan**, Bo Yu, Yu Wang. "Robotic Computing on FPGAs", In *Synthesis Lectures on Computer Architecture*, Morgan & Claypool Publishers, 16(1), pp.1-218, 2021. [PDF]

Preprint Papers

[P4] Yu-Shun Hsiao*, **Zishen Wan***, Tianyu Jia, Radhika Ghosal, Arijit Raychowdhury, David Brooks, Gu-Yeon Wei, Vijay Janapa Reddi. "MAVFI: An End-to-End Fault Analysis Framework with Anomaly Detection and Recovery for Micro Aerial Vehicles", *arXiv preprint arXiv:2105.12882*, 2021. [PDF] **(*Equal contributions with alphabetical order)**

[P3] Srivatsan Krishnan, **Zishen Wan**, Kshitij Bhardwaj, Paul Whatamough, Aleksandra Faust, Sabrina M. Neuman, Gu-Yeon Wei, David Brooks, Vijay Janapa Reddi. "Autopilot: Automating SoC Design Space Exploration for SWaP Constrained Autonomous UAVs", *arXiv preprint arXiv:2102.02988*, 2021. [PDF]

[P2] Srivatsan Krishnan, Thierry Tambe, **Zishen Wan**, Vijay Janapa Reddi. "AutoSoC: Automating Algorithm-SoC Co-Design For Aerial Robots", *arXiv preprint arXiv:2109.05683*, 2021. [PDF]

[P1] Thierry Tambe, En-yu Yang, **Zishen Wan**, Yuntian Deng, Vijay Janapa Reddi, Alexander Rush, David Brooks, Gu-Yeon Wei. "Adaptivfloat: A Floating-point Based Data Type for Resilient Deep Learning Inference," *arXiv preprint arXiv:1909.13271*, 2019. [PDF]

Conference Papers

[C6] **Zishen Wan**, Aqeel Anwar, Yu-Shun Hsiao, Tianyu Jia, Vijay Janapa Reddi, Arijit Raychowdhury. "Analyzing and Improving Fault Tolerance of Learning-Based Navigation System", in *ACM/IEEE Design Automation Conference (**DAC**)*, 2021. [PDF]

[C5] **Zishen Wan***, Yuyang Zhang*, Arijit Raychowdhury, Bo Yu, Yanjun Zhang, Shaoshan Liu. "An Energy-Efficient Quad-Camera Visual System for Autonomous Machines on FPGA Platform", In *IEEE International Conference on Artificial Intelligence Circuits and Systems (**AICAS**)*, 2021. [PDF]

[C4] Tian Gao*, **Zishen Wan***, Yuyang Zhang, Bo Yu, Yanjun Zhang, Shaoshan Liu, Arijit Raychowdhury. "iELAS: An ELAS-Based Energy-Efficient Accelerator for Real-Time Stereo Matching on FPGA Platform", In *IEEE International Conference on Artificial Intelligence Circuits and Systems (**AICAS**)*, 2021. [PDF]

[C3] Max Lam, Sharad Chitlangia, Srivatsan Krishnan, **Zishen Wan**, Gabriel Barth-Maron, Aleksandra Faust, Vijay Janapa Reddi. "ActorQ: Quantization for Actor-Learner Distributed Reinforcement Learning", in *International Conference on Learning Representations (**ICLR**) HEAT Workshop*, 2021. [PDF]

[C2] 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]

[C1] 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 Papers

[J6] **Zishen Wan***, Yu Bo*, Thomas Li, Jie Tang, Yuhao Zhu, Yu Wang, Arijit Raychowdhury, Shaoshan Liu. "A Survey of FPGA-Based Robotic Computing", In *IEEE Circuits and Systems Magazine (**CAS-M**), 21(2), pp.48-74*, 2021. [PDF]

[J5] 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**), vol. 19, issue. 1, pp. 38-42*, 2020. **(Best Paper Award)** [PDF]

[J4] 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]

[J3] 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]

[J2] Peng Xie, Jiarui Liu, Yu Wen, **Zishen Wan**, Yishan Wang. "Influences of Second-order and Third-order Dispersion on Spectral Properties of Mid-Infrared Wavelength Conversion in Silicon Nitride Waveguides," In *Modern Physics Letter B, 33(21):1950241*, 2019. [PDF]

[J1] 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]

Thesis

[T1] **Zishen Wan**. "Modulation and Neutral Voltage Balance Control of NPC Three-level Converter," *Undergraduate Thesis, Harbin Institute of Technology*, 2018. [PDF] (**Best Undergraduate Thesis Award**)

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: Reliable Planning in Infrastructure-Vehicle Cooperative Autonomous Driving System

- Proposing and designing a general and intelligent autonomous vehicle planning system that is reliable, safe, and flexible, with consideration of infrastructure-guided cooperative driving, communications, and control variations.

Project: Analysis and Improvement the Reliability of Autonomous Vehicles [C6]

- Developing a fault injection toolchain that emulates various types of hardware faults to enable rapid fault analysis of complex cyber-physical autonomous navigation systems.
- Characterizing and evaluating the resilience of end-to-end learning-based autonomous navigation systems, with respect to various types of algorithms, fault models, and datatypes, from both single-agent and collaborative multi-agent scenarios.
- Proposing low-overhead efficient fault mitigation techniques to detect and recover faults effects to improve the reliability and safety of autonomous vehicle systems.

Project: Energy-efficient and Reliable Hardware Accelerator for Autonomous Systems [B1, C4, C5, J6]

- Designing a heterogenous SoC with specialized accelerators and general-purpose processors to accelerate full-stack robotic computing, with consideration of emerging non-volatile memory technologies.
- Designing and Implementing energy-efficient and high-performance hardware accelerators for real-time robotic perception (ORB, ELAS) and localization (SLAM) on FPGA platforms.

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 Analysis with End-to-End Anomaly Detection and Recovery [P4]

- Proposed a reliability analysis framework (MAVFI tool) to study the resilience of MAV and other autonomous machines 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 little compute overhead.

Project: Agile System Design Flow for End-to-End (E2E) Learning-Based Aerial Autonomous Machine [P2, P3, J5]

- 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: Quantization Study on Reinforcement Learning Systems [C1, C3]

- Proposed a novel reinforcement learning training paradigm, ActorQ, for speeding up actor-learner distributed RL training.
- 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 [P1, C2]

- Proposed and implemented AdaptivFloat, a novel numeric for resilient deep learning inference. Performed quantization experiments on integer, AdaptivFloat, Bfloat, floating-point, and posit encodings across a diverse set of CNN, RNN, and Transformer models. 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 [J1, J2, J3, J4]

- 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 [T1]

- 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.

INVITED TALKS

- "Enabling Reliable and Safe Autonomous Navigation Systems", Center for Brian-Inspired Computing, SRC JUMP Research Center, Virtual, Aug. 2021.
- "Edge Computing on Aerial Robots", School of Electrical and Computer Engineering, Georgia Institute of Technology, Virtual, Sept. 2020.
- "Micro Aerial Vehicle Fault Injection and Detection", John A. Paulson School of Engineering and Applied Sciences, Harvard University, Virtual, July. 2020.

MENTORSHIP

- Katarine Klitzke, computer engineering undergraduate, Georgia Institute of Technology, Jun. 2021- present
- Johnathan Law, computer engineering undergraduate, Georgia Institute of Technology, Jun. 2021- present
- Prateek Pinisetti, computer science undergraduate, Harvard University, April. 2020 - Aug. 2020

SELECTED AWARDS

- Best Paper Award in IEEE Computer Architecture Letter (CAL) (3/42) Dec.2020
- Best Paper Award in ACM/IEEE Design Autonomation Conference (DAC) (1/267) Jul.2020
- Dean's Fellowship, Purdue University (2 of over 1600 applicants) (declined) Feb.2020
- Best Undergraduate Thesis Award (Top 1%) Jun.2018
- Top Ten Outstanding Graduates, HIT (Top 1%) Jun.2018
- Outstanding Graduates National Undergraduate Electronics Design Contest, China Aug.2017
- Honorable Mention (Team leader), America MCM/ICM Competition, USA Feb.2016 & 2017
- Second Prize (Team leader), The 11th Undergraduate Academic Forum, China Aug.2017
- First Prize (Team leader), National Undergraduate Mathematical Contest in Modeling, China Sept.2016
- Merit Student of Heilongjiang Province (Top 0.1%), Merit Student of Hebei Province (Top 0.1%), China Apr.2016

SELECTED 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++, Cuda, Verilog HDL, SystemC, MATLAB, SQL
- **Tools:** Cadence, Catapult, HSPICE, Quartus, OrCAD, MultiSim, Proteus, Altium Designer, Unreal Engine, AirSim
- **Machine Learning Framework:** Pytorch, TensorFlow, Keras, Caffe, Scikit-learn