

# Lei Zhao

PhD of Computer Science

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## Research

**Hardware level:** Computer Architecture, In-Memory Computing, Emerging Memory Technology, AI Accelerator Design, Hardware-Software Co-design

**Software level:** Deep Learning, ML Model Optimization and Deployment, Secure Machine Learning, Quantization

## Education

### University of Pittsburgh

PH.D. OF COMPUTER SCIENCE

- Co-advised by Youtao Zhang and Jun Yang

*Pittsburgh, PA, U.S.*

*August 2014 - April 2022*

### Northwestern Polytechnical University

MASTER OF COMPUTER SCIENCE

*Xi'an, Shaanxi, China*

*August 2011 - April 2014*

### Northwestern Polytechnical University

BACHELOR OF SOFTWARE ENGINEERING

*Xi'an, Shaanxi, China*

*August 2007 - July 2011*

## Work Experience

### HEP., USA

ARTIFICIAL INTELLIGENCE RESEARCH LAB

*Postdoc Research Scientist*

*August 2023 - Present*

- Architecture, Algorithms, and system design for ReRAM/CMOS hardware accelerators
- Analog CAM based in-memory computing accelerator design for Transformers

### Meta, Inc., USA

REALITY LABS

*Postdoc Research Scientist*

*January 2022 - August 2023*

- ReRAM based in-memory computing accelerator design for graphics pipeline.
- AR/VR deep learning model optimization for in-house systolic array accelerator / SOC.
- AR/VR deep learning model deployment on SOC in existing head mounted devices.

### National Key Lab of Process Optimization and Intelligent Decision, Ministry of Education, China

SMART MEDICAL SYSTEM TEAM

*Research Intern*

*July 2018 - August 2018*

- Maintaining previously developed privacy-preserving neural network training framework.
- Convert and optimize DNN model into a privacy-preserving friendly fashion.

### National Key Lab of Process Optimization and Intelligent Decision, Ministry of Education, China

SMART MEDICAL SYSTEM TEAM

*Research Intern*

*August 2017 - September 2017*

- Developed a privacy-preserving neural network training framework in C++ with CUDA acceleration.

## Previous Projects

### Machine Learning Accelerators

DESIGNER AND CONDUCTOR

*University of Pittsburgh*

*April 2017 - April 2022*

- Design ASIC accelerators based on existing or emerging memory technologies to improve performance and energy efficiency of machine learning computations with a focus on model security and user privacy.
- Three conference papers in [ICCAD'17] [ICS'19] [DAC'20] and one U.S. patent.

## Privacy-Preserving Medical Data Analysis

RESEARCH ASSISTANT

Hefei University of Technology

August 2017 - August 2018

- Evaluate Neural Networks on medical data with homomorphic encryption to protect patient's private information.
- One journal paper in ACM Transactions on Internet Technology (TOIT).

## Privacy-Preserving Neural Network Framework

DESIGNER AND DEVELOPER

University of Pittsburgh

August 2017 - September 2017

- A neural network framework that targets at privacy-preserving and architecture research.
- Written in C++ and CUDA. Support fixed-point computing, stochastic-computing and homomorphic encryption.
- Open sourced on github: <https://github.com/leizhaocs/ArchNet>.

## Emerging Memory Design

DESIGNER AND CONDUCTOR

University of Pittsburgh

September 2014 - April 2016

- Circuit level optimization of non-volatile memory for machine learning acceleration.
- Developed a cycle-accurate out-of-order architecture simulator based on MIPS ISA. Open sourced on github: <https://github.com/leizhaocs/Monichi>.
- Four conference papers in [ICCD'15] [ISQED'17] [NVMSA'17] [ICCAD'17] and one journal paper in IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (TCAD).

## Publications

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### PHD THESIS

- **Lei Zhao**. (2022). [Secure Accelerator Design for Deep Neural Networks](#). University of Pittsburgh.

### CONFERENCE PROCEEDINGS

- **Lei Zhao**, Luca Buonanno, Ron M. Roth, Sergey Serebryakov, Archit Gajjar, John Moon, Jim Ignowski and Giacomo Pedretti. (2023). [RACE-IT: A Reconfigurable Analog CAM-Crossbar Engine for In-Memory Transformer Acceleration](#). (arXiv:2312.06532)
- **Lei Zhao**, Yuecheng Li, Jae-sun Seo, H. Ekin Sumbul, Edith Beigne, and Dawei Wang. (2023). [ReARVR: A ReRAM-Based DNN Accelerator for Mobile Devices](#). Design Automation Conference (Poster Session). (DAC'23)
- **Lei Zhao**, Youtao Zhang, and Jun Yang. (2022). [A DNN Protection Solution for PIM Accelerators With Model Compression](#). IEEE Computer Society Annual Symposium on VLSI. (ISVLSI'22)
- **Lei Zhao**, Youtao Zhang, and Jun Yang. (2022). [SRA: A Secure ReRAM-Based DNN Accelerator](#). Design Automation Conference. (DAC'22)
- **Lei Zhao**, Youtao Zhang, and Jun Yang. (2021). [Flipping Bits to Share Crossbars in ReRAM-Based DNN Accelerator](#). International Conference on Computer Design. (ICCD'21)
- **Lei Zhao**, Youtao Zhang, and Jun Yang. (2020). [SCA: A Secure CNN Accelerator for both Training and Inference](#). Design Automation Conference. (DAC'20)
- **Lei Zhao**, Quan Deng, Youtao Zhang, and Jun Yang. (2019). [RFacc: A 3D ReRAM Associative Array based Random Forest Accelerator](#). International Conference on Supercomputing. (ICS'19)
- **Lei Zhao**, Youtao Zhang, and Jun Yang. (2017). [AEP: An Error-bearing Neural Network Accelerator for Energy Efficiency and Model Protection](#). International Conference On Computer Aided Design. (ICCAD'17)
- Wen Wen, **Lei Zhao**, Youtao Zhang, and Jun Yang. (2017). [Speeding Up Crossbar Resistive Memory by Exploiting In-memory Data Patterns](#). International Conference On Computer Aided Design. (ICCAD'17)
- **Lei Zhao**, Youtao Zhang, and Jun Yang. (2017). [Mitigating Shift-Based Covert-Channel Attacks in Racetrack Last Level Caches](#). Non-Volatile Memory Systems and Applications Symposium. (NVMSA'17)
- **Lei Zhao**, Lei Jiang, Youtao Zhang, Nong Xiao, and Jun Yang. (2017). [Constructing Fast and Energy Efficient 1TnR based ReRAM Crossbar Memory](#). International Symposium on Quality Electronic Design. (ISQED'17)

- Xianwei Zhang, **Lei Zhao**, Youtao Zhang, and Jun Yang. (2015). [Exploit Common Source-Line to Construct Energy Efficient Domain Wall Memory based Caches](#). International Conference on Computer Design. (ICCD'15)

## JOURNAL ARTICLES

- Zijie Yue, Shuai Ding, **Lei Zhao**, Youtao Zhang, Zehong Cao, M. Tanveer, Alireza Jolfaei, and Xi Zheng. (2020). [Privacy-preserving Time Series Medical Images Analysis Using a Hybrid Deep Learning Framework](#). ACM Transactions on Internet Technology.
- Wen Wen, **Lei Zhao**, Youtao Zhang, and Jun Yang. (2019). [Exploiting In-memory Data Patterns for Performance Improvement on Crossbar Resistive Memory](#). IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems.

## Patents

- Youtao Zhang, **Lei Zhao**, and Jun Yang. (2019). [System and method of deploying an artificial neural network on a target device](#). U.S. Patent, 11,531,877 B2.
- Shuai Ding, **Lei Zhao**, Shanlin Yang, Hao Wang and Zijie Yue. (2020). [The architecture, image processing method and process of an artificial intelligence chip for medical endoscope](#). Chinese. Patent, CN108055454B.

## Skills

**Programming** C/C++, Python, Java, CUDA

**Algorithms** Deep Learning, Reinforcement Learning, Homomorphic Encryption

**Tools** Gem5, DRAMSim2, numpy, PyTorch, Homomorphic Encryption Libraries(SEAL, HEAAN), Linux/Unix

## Honors & Awards

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|------|------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| 2021 | <b>Best Paper Candidate</b> , 39th International Conference on Computer Design (ICCD)                      | <i>Virtual Conference<br/>Santa Clara,<br/>CA, USA</i> |
| 2017 | <b>Best Paper Candidate</b> , 18th International Symposium on Quality Electronic Design (ISQED)            | <i>Xi'an, Shaanxi,<br/>China</i>                       |
| 2014 | <b>Outstanding Master Degree Thesis</b> , Graduation Commencement of Northwestern Polytechnical University |                                                        |