

Peiyi He

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Research Interests

In-memory Computing, Neuromorphic Computing, Bioinformatics, Computational Biology

Education

Tsinghua University, B.Eng. in Microelectronics Science and Engineering June 2023

- **Thesis:** Memristor-based content addressable memory design for few-shot learning

The University of Hong Kong, Ph.D. student in Electronic Engineering June 2027 (expected)

- **Thesis:** Fast and efficient genomic analysis with emerging in-memory computing hardware

Projects

ShiftCAM: a time-domain edit distance tolerant content addressable memory

- Developed a time-domain content addressable memory using Shifted Hamming Distance to tolerate insertion and deletion, time-domain circuit discharging behavior is utilized to implement bit-wise AND logic of Shifted Hamming Distance
- Designed a hardware-friendly modification to accidental match (MAM) strategy to overcome potential false positives matches during the shift operations
- Validated the robustness of ShiftCAM considering real RRAM device variation and non-idealities, with physical RRAM device statistical measurements and commercial CMOS PDK
- Extensively evaluated ShiftCAM in downstream genome classification applications, showing significant better F1 score improvement compared to state-of-the-art accelerator

Real-time raw signal genomic analysis using fully integrated memristor hardware

- Proposed a direct nanopore raw signal alignment method using in-memory computing hardware for real-time genome analysis, which effectively combined basecalling and read mapping
- Designed a fuzzy seeding technique using locality-sensitive hashing in memristor crossbar to tolerate large "stay" and "skip" errors in nanopore raw signal
- Introduced a fuzzy seed-and-vote algorithm for memristor-based content addressable memory, enabling fast and accurate raw signal mapping
- Experimentally validated proposed hardware-software co-design in a 180 nm memristor chip, showing that raw signals can be accurately identified
- Extensively evaluated the proposed method with real R9.4.1 nanopore raw signals and simulated R10.4.1 raw signals in various real-time applications, including virus detection and metagenomic profiling

Publications

- **He P**, Wang S, Mao R, et al. Real-time raw signal genomic analysis using fully integrated memristor hardware[J]. Nature Computational Science, 2025.
- **He P**, Mao R, Shan K, et al. ShiftCAM: A Time-Domain Content Addressable Memory Utilizing Shifted Hamming Distance for Robust Genome Analysis[C]. Proceedings of the 43rd IEEE/ACM International Conference on Computer-Aided Design (ICCAD). 2024: 1-9.
- Geng X, Zhang H, Ren J, **He P**, et al. High-performance single crystal CH₃NH₃PbI₃ perovskite x-ray detector[J]. Applied Physics Letters, 2021.

Skills

Programming Languages: Python, Verilog, Matlab, C++

On-going Work: Tapeout, PCB design, Verilog and Python firmware for RRAM chip measurement