Johnny Rhe

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Research Interests

I am currently pursuing **a combined M.S/Ph.D. degree** in the Department of Electrical and computer engineering at SungKyunKwan University. My research focuses on Deep/Convolutional Neural Network (D/CNN) mapping in the Processing-In-Memory (PIM) architecture for **energy-efficient and faster PIM-based D/CNN inference.** To achieve this goal, I am exploring diverse approaches including weight mapping, pattern-based pruning, and kernel shape control.

Education

Combined M.S-Ph.D. Electrical and Computer Engineering *Sept. 2019 - Present*

SungKyunKwan University, Suwon, Korea

- Intelligent & Resource-Efficient Image Processing & Systems Design (IRIS) Lab
- **Thesis Advisor: Prof. Jong Hwan Ko**

B.S. School of Electronic and Electrical Engineering *Mar. 2011 - Feb. 2019*

SungKyunKwan University, Suwon, Korea

Research Experience

Graduate Research Assistant in SungKyunKwan University *Sept. 2019 - Present*

1. Optimal Weight Mapping Method for Energy-efficient and Faster PIM-based Inference

- Designed a weight mapping method for minimizing energy consumption and computing cycles.
- Implemented a simulation to calculate the total computing cycles based on weight mapping.
- Proposed a novel weight mapping approach for energy-efficient PIM-based inference.
- Proposed a channel pruning algorithm paired with the weight mapping methods.

2. Weight Pattern Design for PIM Architectures

- Designed a pattern using a weight sparsity for reducing computing cycles.
- Proposed pattern shapes for the SDK-based mapping method to compress the weight matrix.

3. Improving the Utilization by Handling Idle Memory Cells

- Studied how to utilize unused memory cells.
- Designed network training scheme with kernel shape control for more memory cells to be used.
- Proposed a novel method to generate various kernel shapes substitute for weight pruning.

4. Visualization & Simulation of Weight Mapping Methods

- Implemented a simulation with visualizing the weight mapping in PIM arrays.

Student Activites

[S4] Best Paper Award, Juhong Park, **Johnny Rhe** and Jong Hwan Ko, "KARS: Kernel-Grouping Aided Row-skipping for SDK-based Weight Compression in Processing-In-Memory Architectures". *July, 2023*

Korean Artificial Intelligence Association

[S3] SKKU Innovation Research Fellowship Scholarship Selection *Oct, 2022*

BK Graduate School Innovation Support Project

[S2] Introduction and Demonstration of RC Car Remote Control Using 3D Hand Motion Recognition *Apr, 2022*

Information Technology Research Center (ITRC), Korea

[S1] 2^{nd} Place Winner of Artificial Intelligence Grand Challenge *July, 2020*

Institute of Information & Communications Technology Planning & Evaluation, Korea

Publications

Journal Articles

[J3] Gicheol Shin, Donguk Seo, Jaerok Kim, **Johnny Rhe**, Minhueok Jeong, Eunyoung Lee, Seongo Kim, Soyoun Jeong, Jong Hwan Ko, and Yoonmyung Lee, "All Charge Domain Variable-Precision Computation-In-Memory Macro Using All-Around-Wire-Capacitor," *IEEE Journal of Solid State Circuits (JSSC)*, In review.

[J2] **Johnny Rhe**, Sungmin Moon, and Jong Hwan Ko, "VWC-SDK: Convolutional Weight Mapping Using Shifted and Duplicated Kernel with Variable Windows and Channels," *IEEE Journal on Emerging and Selected Topics in Circuits and Systems (JETCAS), vol. 12, no. 2, pp. 408-421*, May. 2022 (impact factor: 5.877).

[J1] Eunyoung Lee, Taeyoung Han, Donguk Seo, Gicheol Shin, Jaerok Kim, Seonho Kim, Soyoun Jeong, **Johnny Rhe**, Jaeyung Park, Jong Hwan Ko, Yoonmyung Lee, "A Charge-Domain Scalable-Weight In-Memory Computing Macro with Dual-SRAM Architecture for Precision-Scalable DNN Accelerators," in *IEEE Transactions Circuits and System I (TCAS-I) vol. 68, no. 8, pp. 3305-3316*, May. 2021.

Conference Proceedings

[C7] Kang Eun Jeon[1], Wooram Seo[1], **Johnny Rhe**, and Jong Hwan Ko, "ConvMapSim: Modeling and Simulating Convolutional Network Mapping on PIM Arrays," *IEEE International Conference on Computer Design (ICCD 2023)*, In review.

[C6] Hyeonsu Bang, Kang Eun Jeon, **Johnny Rhe**, and Jong Hwan Ko, "DCR: Decomposition-Aware Column Re-Mapping for Stuck-At-Fault Tolerance in ReRAM Arrays," *IEEE International Conference on Computer Design (ICCD 2023)*, In review.

[C5] **Johnny Rhe**, Kang Eun Jeon, Joo Chan Lee, Seong Moon Jeong, and Jong Hwan Ko, "Kernel Shape Control for Row-Efficient Convolution on Processing-In-Memory Arrays," *ACM/IEEE International Conference on Computer-Aided Design (ICCAD 2023)*, Oct. 2023.

[C4] **Johnny Rhe**, Kang Eun Jeon, and Jong Hwan Ko, "PAIRS: Pruning-AIded Row-Skipping for SDK-Based Convolutional Weight Mapping in Processing-In-Memory Architectures," *ACM/IEEE International Symposium on Low Power Electronics and Design (ISLPED 2023)*, Aug. 2023.

[C3] Kang Eun Jeon, **Johnny Rhe**, and Jong Hwan Ko, "Weight-Aware Activation Mapping for Energy-Efficient Convolution on PIM Arrays," *ACM/IEEE International Symposium on Low Power Electronics and Design (ISLPED 2023)*, Aug. 2023.

[C2] **Johnny Rhe**, Sungmin Moon, and Jong Hwan Ko, "VW-SDK: Efficient Convolutional Weight Mapping Using Variable Windows for Processing-In-Memory Architectures," *Design, Automation, and Test in Europe (DATE 2022)*, Mar. 2022 (Oral, acceptance rate: 25%).

[C1] Gicheol Shin, Donguk Seo, Jaerok Kim, **Johnny Rhe**, Eunyoung Lee, Seonho Kim, Soyoun Jeong, Jong Hwan Ko, Yoonmyung Lee, "A charge-Domain Computation-in-Memory Macro with Versatile All-Around-Wire-Capacitor for Variable-Precision Computation and Array-Embedded DA/AD Conversions," *European Conference on Solid-State Circuits (ESSCIRC 2021)*, Sept. 2021.

Patents

[P3] **Johnny Rhe**, Sungmin Moon, and Jong Hwan Ko, US Patent Application No.18090628, Memory device for optimizing computation of convolutional layer, method for controlling memory device, and recording medium storing instructions to perform method for controlling memory device, Dec. 2022.

[P2] **Johnny Rhe** and Jong Hwan Ko, Korean Patent Application No.10-2022-0187676, Apparatus, method, computer-readable storage medium and computer program for controlling processing-in-memory by accelerating convolution operation based on arranging pattern of weight in kernel, Dec. 2022.

[P1] **Johnny Rhe**, Sungmin Moon, and Jong Hwan Ko, Korean Patent Application No.10-2021-0191289, Memory device for optimizing operation of convolutional layer and method for controlling the same, Dec. 2021.

Reference

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