UNIVERSITY OF SOUTH FLORIDA

Defense of a Doctoral Dissertation

Exploration of Energy Efficient Computing for Data Intensive Applications

by

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For the Ph.D. degree in Computer Science and Engineering

The recent surge of data-intensive applications has stretched the performance and energy limit of today's traditional computing system. The massive amount of data generated by data-intensive applications is not processed at the same speed due to bandwidth mismatch between the faster processing unit and slower memory. Memory access and data transfer make up most of the total energy consumption. In light of this, we explore different aspects of two computing systems, namely in-memory computing and AI-enabled edge computing. The primary goal of this research is to explore two paradigms that would enable energy-efficient computing of data-intensive applications by mitigating the number of times memory is accessed and by lessening the bandwidth requirement. The emerging non-volatile memory such as memristor can be utilized to enable in-memory computing system. In this work, we propose a VHDL-based framework that enables us to quickly perform behavioral simulation and estimate the dynamic energy consumption and speed of any large memristive crossbar array. To further the energy-efficient implementation, we propose a novel approach to address the fanout overhead problem. In addition, we examine the impact of high-energy radiation during the in-memory logic computation. High data rate detectors play an integral part in scientific research, and their development is actively pursued at High Energy Physics (HEP) facilities around the world. Edge Machine Learning (ML) offers the ability to reduce data transfer hence energy consumption by integrating ML algorithms into Application Specific Integrated Circuits (ASICs) on the front-end electronics. This work explores a set of neural networks for predicting the peak amplitudes in the detector's sensor response targeting minimal latency and energy consumption.

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Publications

1) B. Olney, S. Mahmud, **M. A. Zaman**, and R. Karam, "An EDA Framework for Design Space Exploration of on-chip AI in Bioimplantable Applications," in IEEE International Midwest Symposium on Circuits and Systems (MWSCAS), 2022
2) S. Miryala*, **M. A. Zaman*** et al., "Peak Prediction Using Multi Layer Perceptron for Edge Computing ASICs Targeting Scientific Applications," in 23nd International Symposium on Quality Electronic Design (ISQED), 2022
3) **M. A. Zaman**, R. Joshi, and S. Katkoori, "Early Design Space Exploration Framework for Memristive Crossbar Arrays," in ACM Journal on Emerging Technologies in Computing Systems, 2021
4) **M. A. Zaman**, R. Joshi, and S. Katkoori, "High Level Modeling of Memristive Crossbar Arrays," in IEEE Computer Society Annual Symposium on VLSI (ISVLSI), 2020
5) **M. A. Zaman**, R. Joshi, and S. Katkoori, "Analysis of Radiation Impact on Memristive Crossbar Arrays," in 11th IEEE LASCAS Latin American Symposium on Circuits and Systems (LASCAS), 2020
6) **M. A. Zaman**, R. Joshi, and S. Katkoori, "Optimizing Performance and Energy Overheads Due to Fanout in In-Memory Computing Systems," Springer International Publishing AG, 2019
7) **M. A. Zaman** and S. Katkoori, "Minimizing Performance and Energy Overheads Due to Fanout In Memristor based Logic Implementations," in 26th IFIP/IEEE International Conference on Very Large Scale Integration(VLSI-SoC), 2018

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