

Bachelor's / Master's / Semester Project

Novel Algorithms and Architectures for Stochastic Computing

Context & background:

Stochastic computing (SC) is an alternative computing paradigm compared to traditional binary computing for various applications such as image and signal processing. Recent works show that SC is promising as it offers (1) elementary operations for complex arithmetic operations (e.g., bit-wise AND instead of multiplication) and (2) high tolerance to noise in the data and computation logic. Despite many advantages, SC still faces challenges, especially in dominant CMOS technologies. Simultaneously, applications SC tends to improve are typically data-intensive. Therefore, a design that uses emerging technologies, such as memristors and data-centric paradigms (widely known as Computation-in-Memory (CIM) or Processing-in-Memory (PIM)) is likely to solve the current problems of SC-based designs and take them one step further.

In this project, you aim to evaluate various applications and their data flow and develop an SC-based design at the algorithmic and/or hardware architecture level to improve the application's overall accuracy, performance, and/or efficiency.

Expected effort:

This project can take shape as a semester, BSc, or MSc project.

In this project, the student will

- find several applications that have the potential to be improved via the SC paradigm
- propose novel algorithm/data mapping/hardware to alleviate the limitations and bottlenecks of previous SC-based designs while outperforming traditional state-of-the-art von Neumann-based works
- develop simulation platforms to evaluate the proposals and previous works fairly

For preliminary readings please see:

- Alam, et al., "[Stochastic Computing in Beyond Von-Neumann Era: Processing Bit-Streams in Memristive Memory.](#)" IEEE Transactions on Circuits and Systems II: Express Briefs, 2022.
- Alam, et al., "[Exact in-memory multiplication based on deterministic stochastic computing.](#)" In ISCAS, 2020.
- Xie, et al., "[Scouting logic: A novel memristor-based logic design for resistive computing.](#)" In ISVLSI, 2017.
- Shafiee, et al., "[ISAAC: A convolutional neural network accelerator with in-situ analog arithmetic in crossbars.](#)" ISCA, 2016.
- Ghose, et al., "[Processing-in-memory: A workload-driven perspective.](#)" IBM Journal

of Research and Development, 2019.

- Hamdioui, et al., "[Memristor based computation-in-memory architecture for data-intensive applications.](#)" DATE, 2015.

Requirements:

- Outstanding programming skills
- Good knowledge of design and analysis of algorithms and data structures
- An interest in developing and evaluating new ideas, discovering why things do or do not work, making systems efficient and usable
- Strong work ethic

Plus Points:

- Background in approximate computing or stochastic computing
- Background in CIM
- Background in computer architecture
- Knowledge in spice simulation

Contact information:

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