Exploiting Error Resilience of Iterative and Accumulation based Algorithms for Hardware Efficiency

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Introduction

- While the efficiency gains due to process technology improvements are reaching the fundamental limits of computing, emerging paradigms like approximate computing provide promising efficiency gains for error resilient applications [1].
- Keeping in view a wide range of iterative and accumulation based algorithms in digital signal processing, this thesis investigates systematic approximation methodologies to design high-efficiency accelerator architectures for such algorithms.
- As a case study of such algorithms, we have applied our proposed approximate computing methodologies to a radio astronomy calibration application [7].

Energy-efficient Accelerator Design for Iterative Algorithms

- Our proposed error-resilience analysis methodology, adaptive statistical approximation model [3], provides a way to quantify the number of iterations that can be processed using an approximate core while complying with the quality constraints.

Self-healing Methodology for Accumulation based Algorithms

Unlike the conventional approximate design methodology, the proposed self-healing [5] methodology provides the following benefits,

- Increased approximation space
- Error cancellation for the intermediate computing stage
- A more effective quality-efficiency trade-off

Internal self-healing

We further propose an internal self-healing methodology [6] that allows exploiting self-healing within a computing element, internally, without requiring a parallel module. This extends the applicability of self-healing methodology to irregular datapaths.

References (Publications List)

[3] CF’17: https://doi.org/10.1145/3075564.3078991
[5] SquASH: https://doi.org/10.1109/ACCESS.2018.2868036
[6] MACISH: https://doi.org/10.1109/ACCESS.2019.2920335

Conclusions

This research has contributed towards effective error resilience analysis and energy-efficient accelerator design for iterative algorithms like radio astronomy calibration algorithm. Moreover, for accumulation based algorithms like multiply-accumulate, our self-healing and internal self-healing methodologies provide a more effective quality-efficiency trade-off as compared to the state-of-the-art approximate computing methodology.

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