REACT: A Framework for Rapid Exploration of Approximate Computing Techniques

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Motivation

Understand current research

Investigate new techniques

Evaluate impact of existing techniques
Taxonomy

Determinism

\[ |P(x) - A(x)| \leq \varepsilon \forall x \]
\[ \Pr(|P(x) - A(x)| > \varepsilon) < P \forall x \]

Granularity

Hardware/Software

Computational Resource(s)
<table>
<thead>
<tr>
<th></th>
<th>Nondeterministic</th>
<th>Deterministic</th>
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<tbody>
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<td><strong>Fine Grained</strong></td>
<td>DRAM Refresh Rate</td>
<td>Bit-Width Reduction</td>
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<td></td>
<td>SRAM Soft Error Exposure</td>
<td>Float-to-Fixed Conversion</td>
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<td>Approximate Storage (PCM)</td>
<td>Fuzzy Memoization</td>
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<td></td>
<td>Soft Fault Tolerance</td>
<td>Hierarchical FPU</td>
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<td>Synchronization Elision</td>
<td>Load Value Approximation</td>
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<td></td>
<td>Voltage Overscaling</td>
<td>Lossy Compression and Data Packing</td>
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<td>Precision Scaling ALU</td>
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<td>Reduced-Precision FPU</td>
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<td>Underdesigned Multiplier</td>
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<td><strong>Coarse Grained</strong></td>
<td>Error Handling (Recovery, Debugging)</td>
<td>Algorithm Selection</td>
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<td>Neural Acceleration (Analog)</td>
<td>Code Perforation</td>
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<tr>
<td></td>
<td>(ASIC, FPGA, GPU)</td>
<td>Interpolated Memoization</td>
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<td></td>
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<td>Neural Acceleration (ASIC, FPGA, GPU)</td>
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<td>Parallel Pattern Replacement</td>
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<td>Parameter Adjustment</td>
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REACT

A Framework for Rapid Exploration of Approximate Computing Techniques
Application Profiler & Energy Model

Intel Pin tool
Insn Count + Arch Events

Custom, linear model
Simple, understandable
Validated against McPAT
Error Injection

ACCEPT
Runtime error injection
Simple API
Arbitrary error models

```c
int i, p;
APPROX int a;
APPROX int data[N];
a = data[i] * p;
```
Approximation Models

Load Value Approximation
Drowsy SRAM
Reduced Precision FPU
Low refresh rate DRAM
Voltage Overscaled ALU
Neural Acceleration
Early Results - Sobel
Early Results – FFT1D

![Graph showing energy savings versus signal-to-noise ratio for various techniques. The graph includes data points for DRAM Refresh, Load Value Approximation, Neural Acceleration, Reduced-Precision FPU, Spatial Accelerator, Voltage Overscaling; DRAM; FPU, and Voltage Overscaling; FPU. The Precise SNR line is also indicated.]
Conclusions

Coarse-grained superior to fine-grained

Coarse-grained, Nondeterministic!
Thank you!

Questions?