Distilling Sparse Linear Algebra

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Problem Statement

Fusion is an ubiquitous optimization for dence applications widely used, e.g., in Tensorflow, aimed to reduce memory usage. Is is also a highly desired optimization in sparse applications [1] but it is hard to implement due to pointer-chaising [2] nature of the latter. The basics of this optimization is the removal of *intermediate* data structures : those which are firstly constructed and then deconstructed. This is common for functional programming where such optimization is often addressed as *deforestation.*

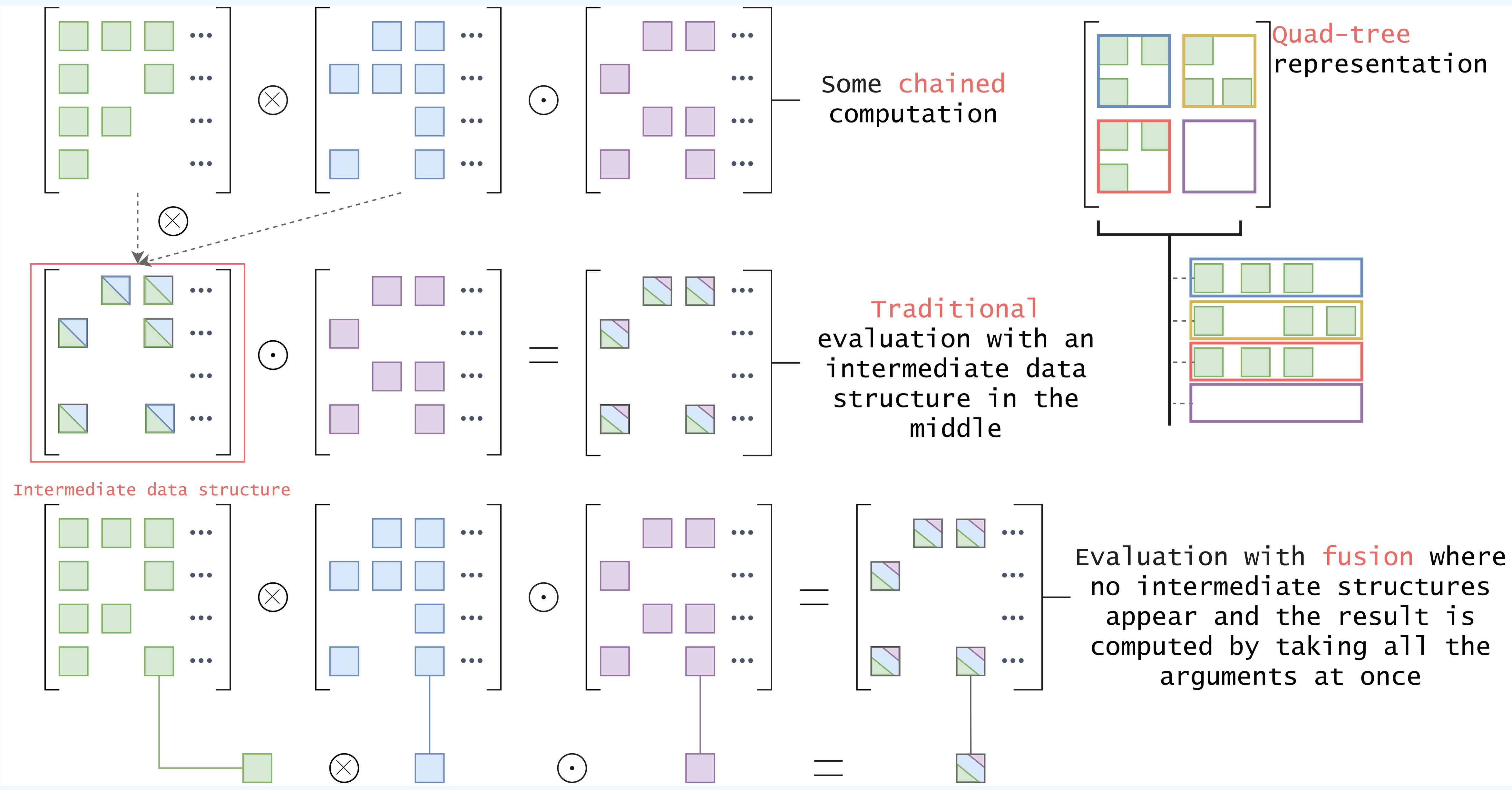
We propose the usage of a functional *quad-tree* represenation for sparse data and *disillation* to support fusion for sparse applications.

Distillation

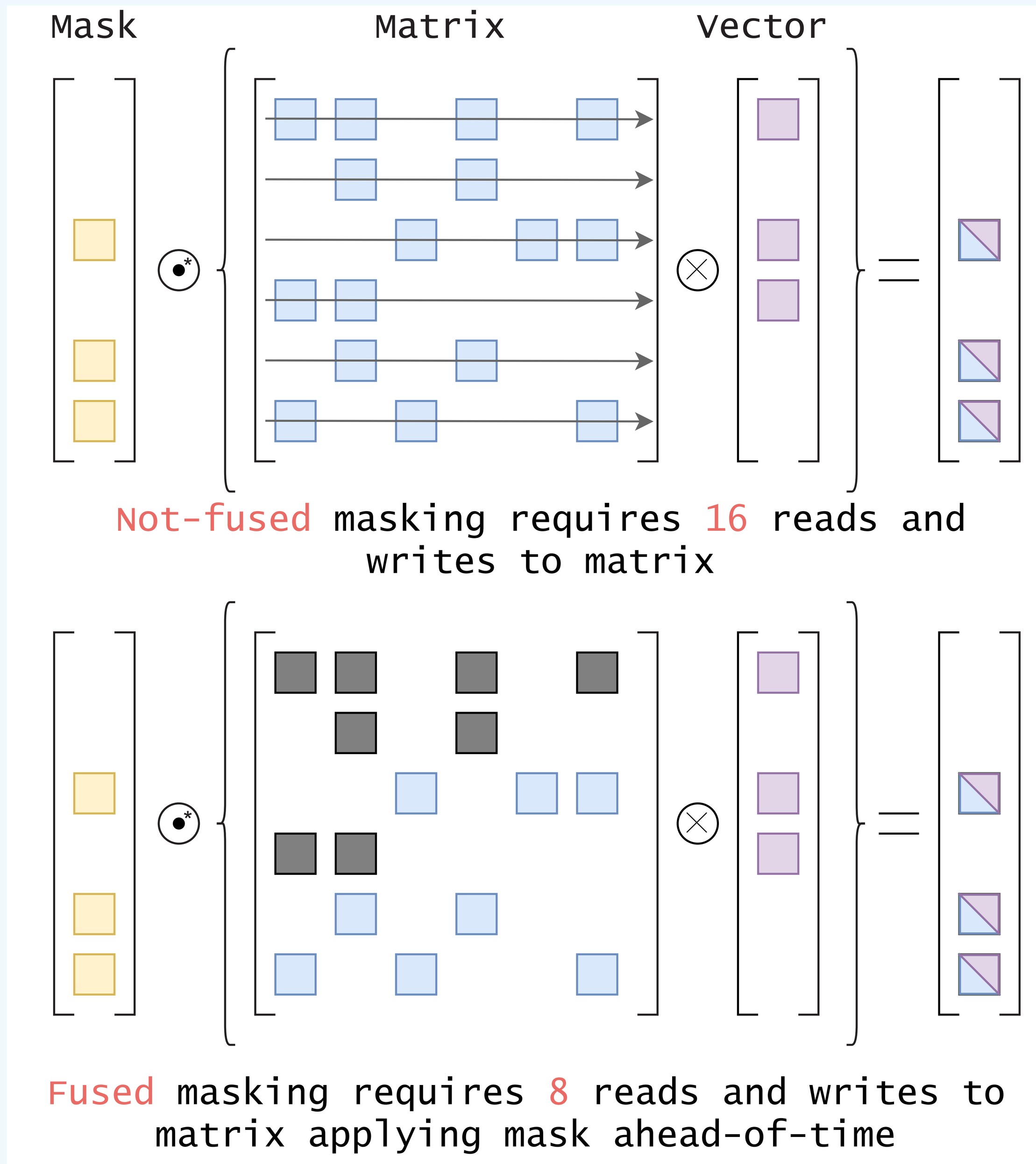
Distillation implements deforestation by removing intermediate data structures, i.e. those first constructed and then deconstructed, providing the following bonuses

- Specialization, i.e., it partially evaluates the program on statically known arguments.
- Yields *tail recursive modulo cons* programs, which could ease the following translation to hardware.
- Gives potentially assympotically greater speed-up than deforestation.

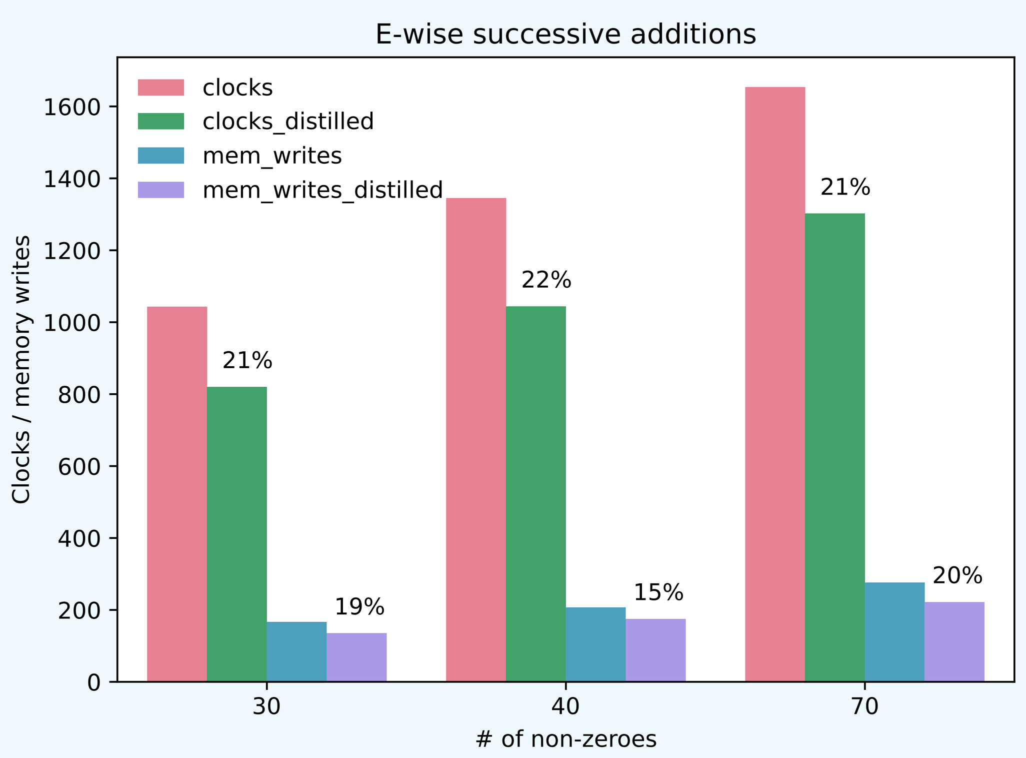
Motivation: Kernel fusion



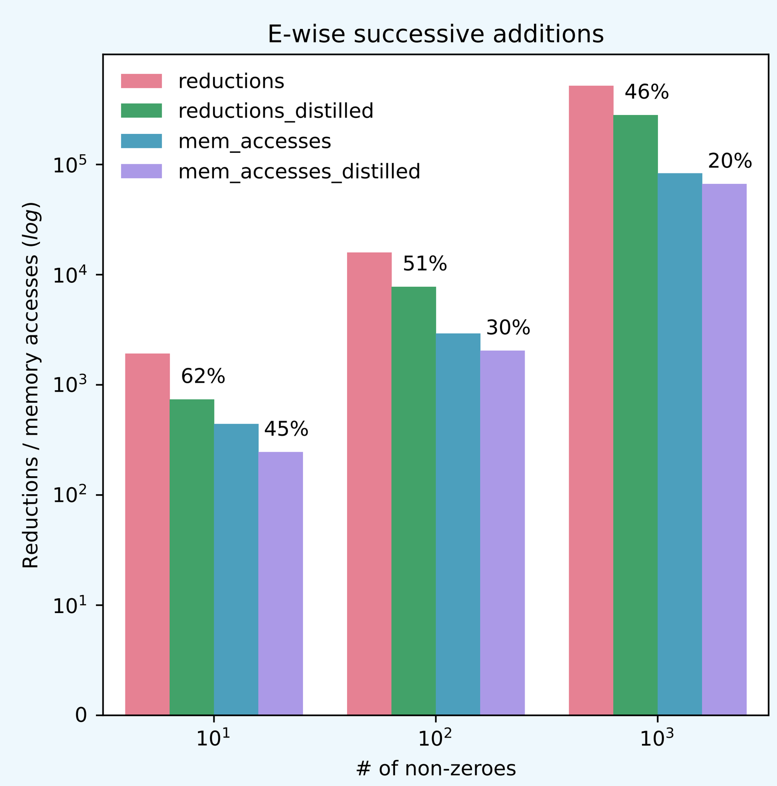
Motivation: Mask fusion [1]

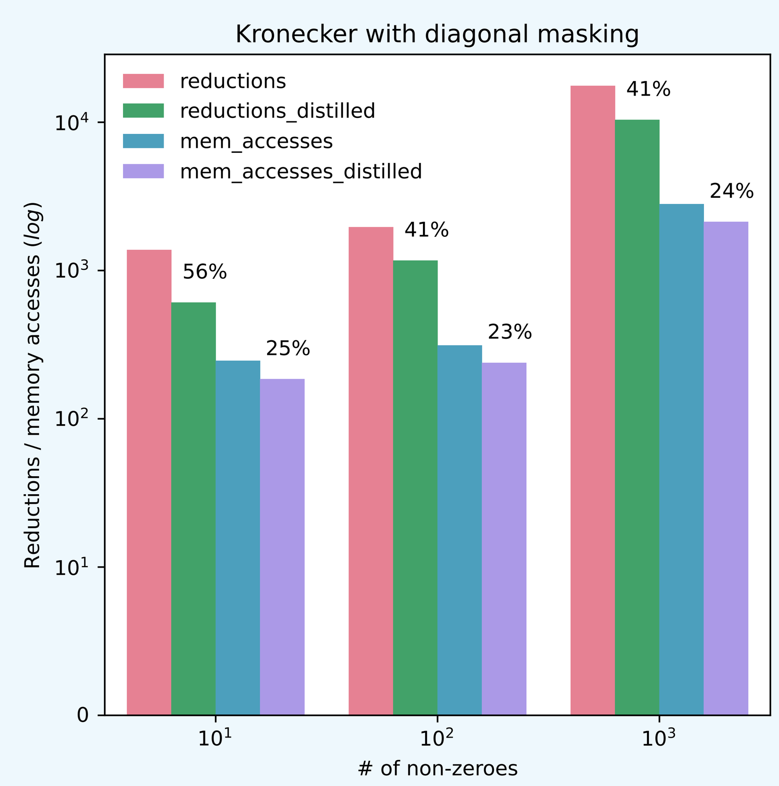


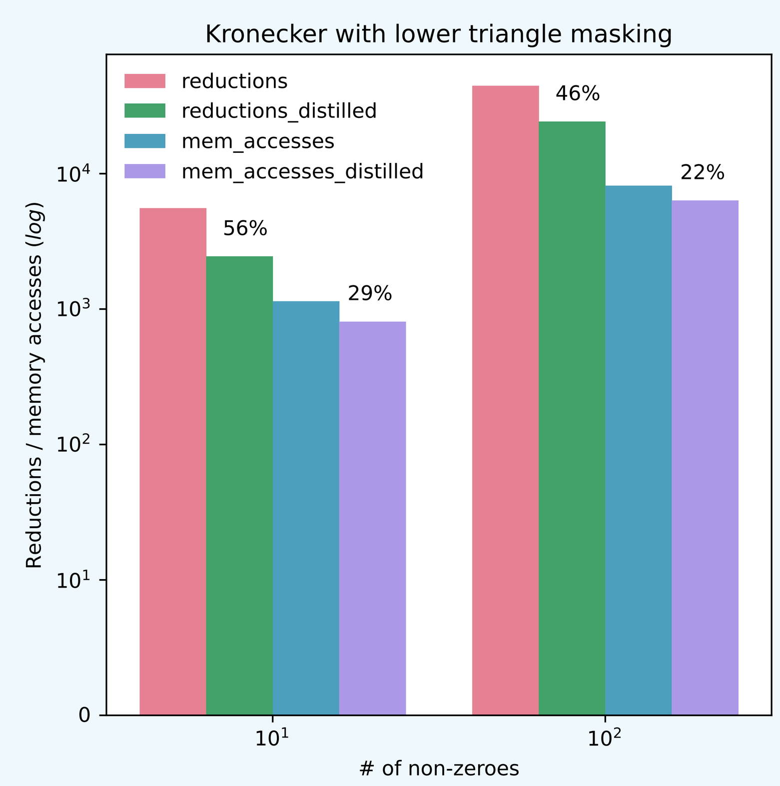
Evaluation: Hardware



Evaluation: Software







Implementation

We use the distiller authored by Geoff Hamilton [3] and its functional language to evaluate the approach in terms of *reductions* and *memory accesses.*
In order to provide both enough performance and interoperability with C++ (in which modern sparse frameworks are mostly written) we aim to synthesize a FPGA kernel from distilled functional program and utilize FHW project [4] to do so.

Results

Distillation gives prominent results namely

- Shows up to **60%** less reductions and **45%** less memory accesses in software.
- Shows up to **20%** less clock cycles and memory writes in hardware.

Future Research

- Moving the disiller from proof-of-concept to ready-to-use.
- Moving the hardware compiler from proof-of-concept to ready-to-use.
- Bridge the gap between our approach and existing sparse frameworks in a form of OpenCL-like kernels.
- Real-world examples evaluation.

Contact Us

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References

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[3] Geoff Hamilton. Extracting the essence of distillation. pages 151–164, 06 2009.

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