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To cite this version:

HAL Id: hal-01666818
https://hal-mines-paristech.archives-ouvertes.fr/hal-01666818
Submitted on 18 Dec 2017

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Towards Compositional and Generative Tensor Optimizations

Adilla Susungi, Norman A. Rink, Jerónimo Castrillón, Immo Huismann, Albert Cohen, Claude Tadonki, Jörg Stiller and Jochen Fröhlich

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Tensor Optimization Frameworks

- Domain-specific expressivity
- Flexible/Adaptive optimization heuristics
- Hidden and/or rigid optimization heuristics
- Generic expressivity

Related Work

- Different levels of expressiveness and control on optimizations
  - Flexible/adaptive
  - Hidden/rigid

Tensor Optimization Frameworks

- Several limitations
- Few opportunities for adaptations

Optimizing CFD Kernels with Existing Tools

- Limited expressivity
- Limited optimizations
- Unadapted heuristics
- Unadapted constructs

Goal

A cross-domain intermediate language for tensor optimizations

Intermediate Language

- Modular constructs
- First-class citizens:
  - Arrays
  - Tensor operators
  - Loop iterators
  - Transformations

Envisioned Tool

- Meta-programming
- Iterative search
- Generic expressivity
- Flexible/Adaptive optimization heuristics

Search Space Exploration

- Evaluation order of tensor contractions
- Fusions
- Permutations
- Vectorization
- Collapsing
- Unrolling

Inverse Helmholtz by Example

```
# Basic array declaration
A = array(2, double, [N, N])
u = array(3, double, [N, N, N])
D = array(3, double, [N, N, N])

# Transposition
At = vtranspose(A, 1, 2)

# Tensor contractions
tmp1 = contract(At, u, [2, 1])
tmp2 = contract(At, tmp1, [2, 2])
tmp3 = contract(At, tmp2, [2, 3])

# Iterator declaration
i1 = iterator(0, N, 1)
i2 = iterator(0, N, 1)

# Assocation of iterators to computations
build(D, [td1, td2, td3])
build(v, [k12, k22, k32, k42])
```

Future Work

- Applications to other domains
- Syntax refinement
- Formal semantics

This work was partially funded by the German Research Council (DFG) through the Cluster of Excellence ‘Center for Advancing Electronics Dresden’ (cfaed) and by PSL Research University through the ACOPAL project.