Towards Compositional and Generative Tensor Optimizations

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

To cite this version:

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

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Towards Compositional and Generative Tensor Optimizations
Adilla Susungi, Norman A. Rink, Jerónimo Castrillón, Immo Huismann, Albert Cohen, Claude Tadonki, Jörg Stiller and Jochen Fröhlich

adilla.susungi@mines-paristech.fr — norman.rink@tu-dresden.de

Tensors in Computational Fluid Dynamics (CFD)

Loop characteristics:
- 3 to 4 dimensions nesting
- Few iterations per dimension (e.g., 17 or 33 iterations)

Type of computations:
- Tensor contractions
- Outer products
- Element-wise multiplications
- Computations on each element of a structured mesh

Inverse Helmholtz
\[ t_{ijk} = \sum_{l,m,n} A^T_{kn} \cdot A^T_{jm} \cdot A^T_{il} \cdot \omega_{lmn} \]
\[ p_{ijk} = D_{ijk} \cdot t_{ijk} \]
\[ v_{ijk} = \sum_{l,m,n} A_{kn} \cdot A_{jm} \cdot A_{il} \cdot p_{lmn} \]

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

Optimizing CFD Kernels with Existing Tools

- Several limitations
- Few opportunities for adaptations
- Unadapted heuristics
- Unadapted constructs

Should we create yet another domain-specific solution?

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

Search Space Exploration

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

Inverse Helmholtz by Example

Example of assessment: Different heuristics of loop interchanges (+ parallelization)

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.