Research Project

Acceleration of non-rigid image registration with Tensor Cores

Jonathan LEVY

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Outline

1. My cursus
2. Research Project proposal

Cursus

About me

- Jonathan LEVY
- MSc student in Computer Science
- Wide background in Engineering

Cursus Summary

- *Classe Préparatoire PTSI/PT**
- Ecole Normale Supérieure de Rennes (BSc, Master in Teaching)
- *Agrégation* in Engineering, CS track
- MSc Embedded Systems, TU Delft

Current work

Since September 2019:
GASAL2 : GPU-accelerated library for DNA alignment

When	First as Extra Project, then MSc Thesis
Languages	C/C++ and CUDA
Algorithm	Smith-Waterman - optimal alignment for short pair

Goal: integrate in the *Burrough-Wheeler Aligner, "BWA"*

https://github.com/j-levy/GASAL2

https://github.com/j-levy/bwa-gasal2 ← private repository

Acceleration of non-rigid image registration with Tensor Cores

- Image registration: aligning a *floating* image with a *reference*.
- *Non-rigid*: various deformations allowed
- Use GPU for parallel calculation

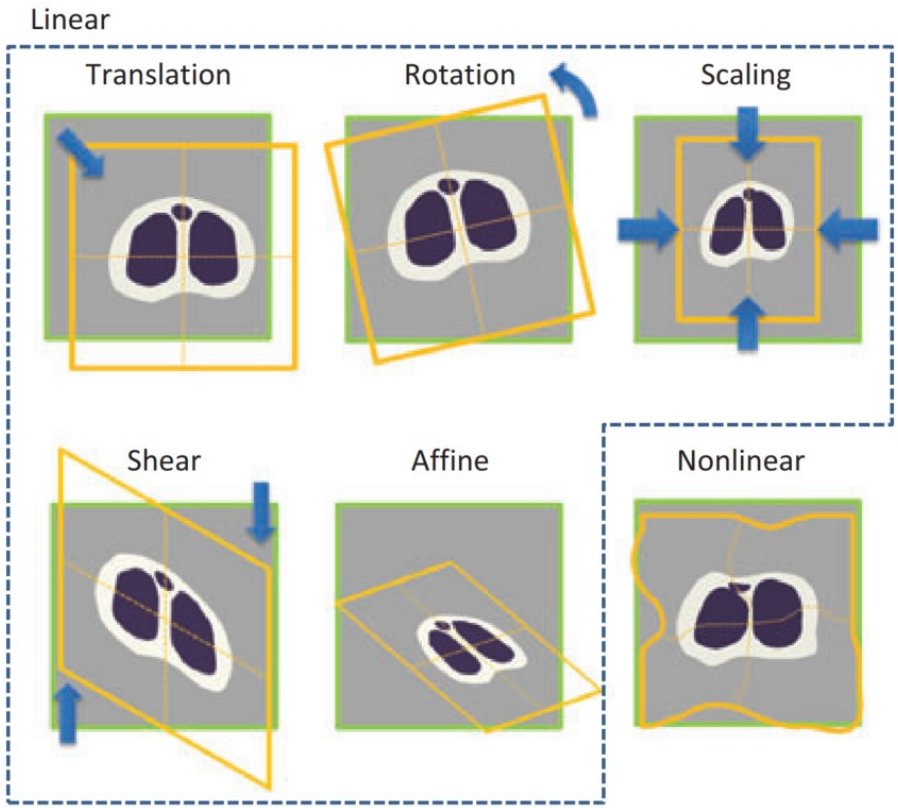

Figure 1: Different types of deformation.

The Volta Architecture

- NVIDIA GPUs' architecture (2017)
- Several changes:
  - HBM2 memory
  - Parallel FP/Integer calculation
  - Tensor Cores

Figure 2: The full GV100 architecture

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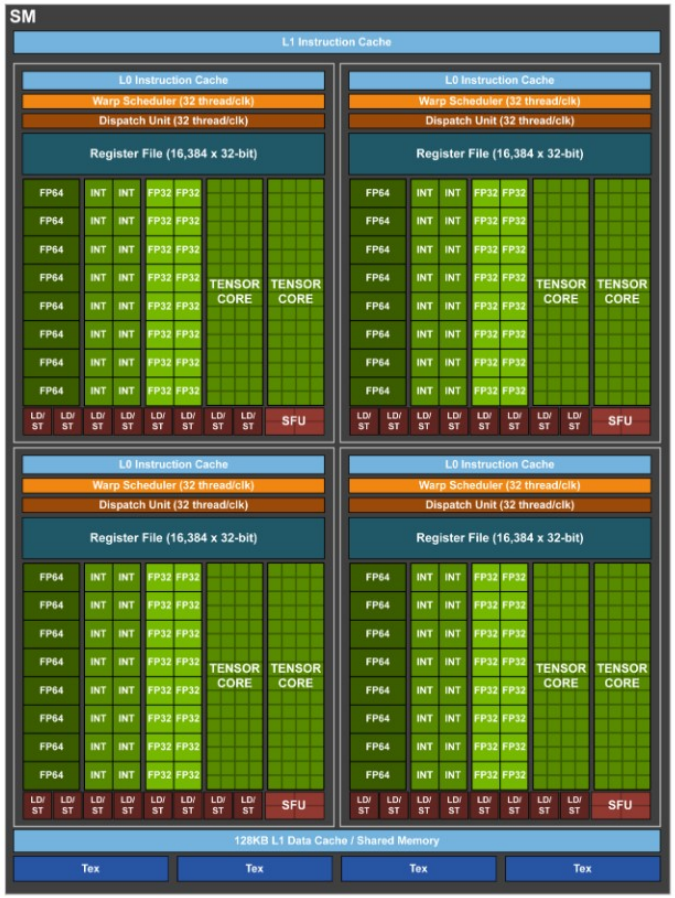

Figure 2: Volta Streaming Multiprocessor (80 units per GV100)

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Figure 2: Volta Processing Block (4 units per SM)

Tensor Cores

WHAT Matrix-matrix multiplication

HOW Mixed precision

WHY Deep Learning

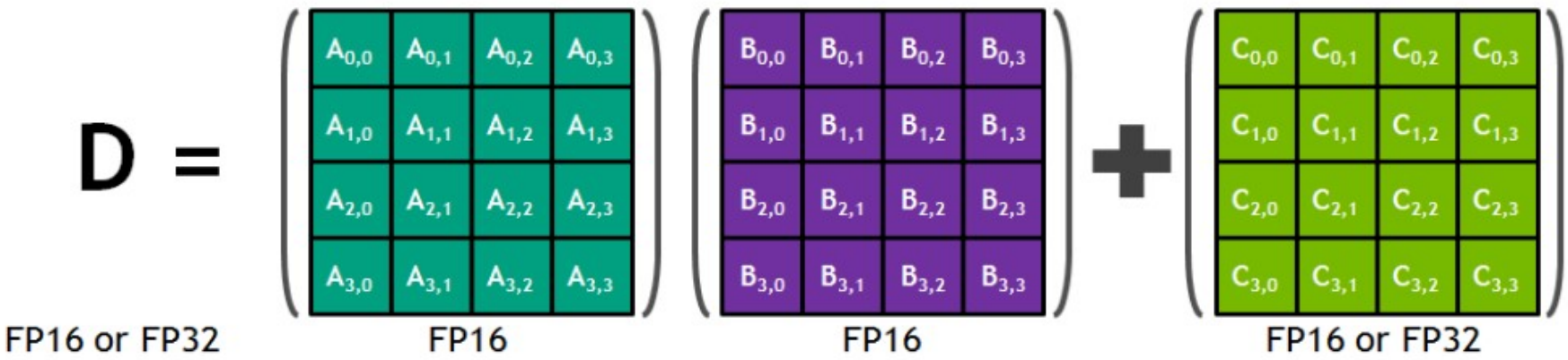

Figure 3: Operation done by a Tensor Core

Registration steps

B-Splines model

GOAL Find optimal transformation $T : (x, y, z) \longmapsto (x', y', z')$

ALGO Spline-based Free-Form Deformation (FFD) : 3D deformation model using net of points $\phi_{x,y,z}$

$$T(x, y, z) = \sum_{l=0}^{3} \sum_{m=0}^{3} \sum_{n=0}^{3} B_l(u)\, B_m(v)\, B_n(w)\, \phi_{i+l,j+m,k+n} \qquad (1)$$

Tensor product $\Longrightarrow$
Calculation by Tensor Cores possible
Each point affects is 4 direct neighbours