

# Optimal Steps for Fast Diffeomorphic Shape Registration

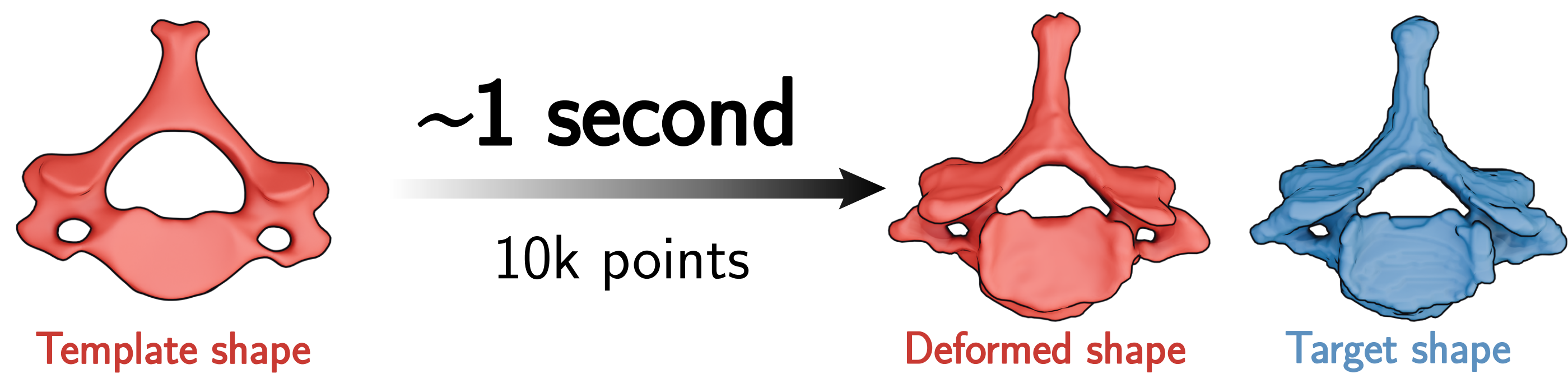
Hadrien Bigo-Balland<sup>1</sup>

Jean Feydy<sup>1</sup>

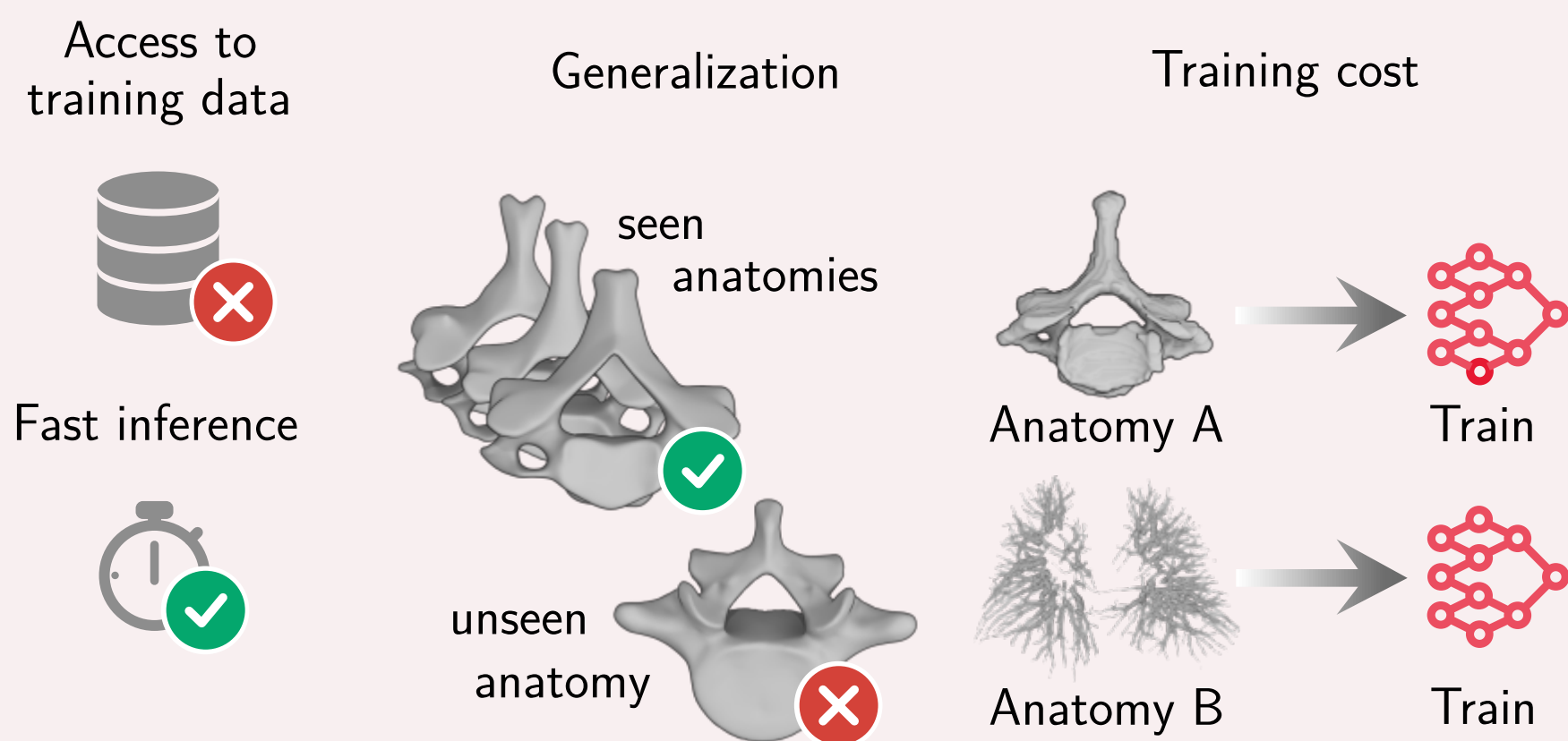
Tom Boeken<sup>1,2</sup>

<sup>1</sup>Inria, Université Paris Cité, Inserm, HeKA, <sup>2</sup>Department of Vascular and Oncological Interventional Radiology, Hôpital Européen Georges Pompidou, AP-HP

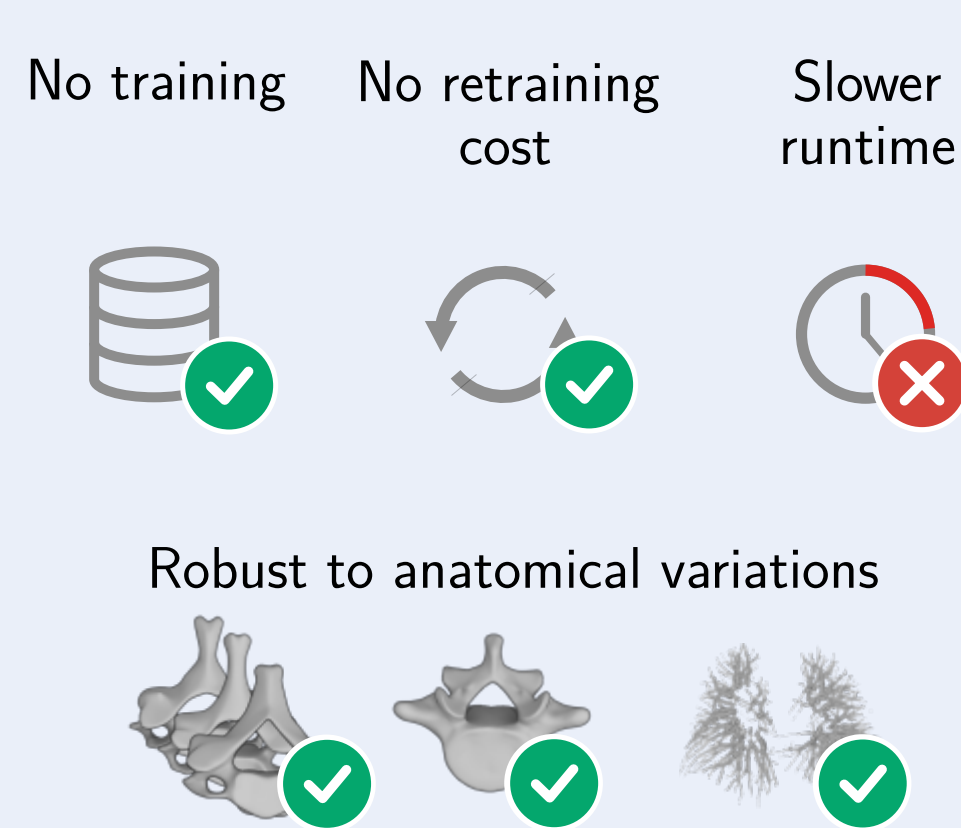
## THE PROBLEM: REGISTER A SHAPE TO ANOTHER



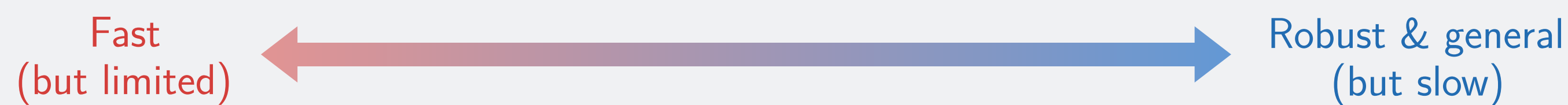
### Deep learning registration



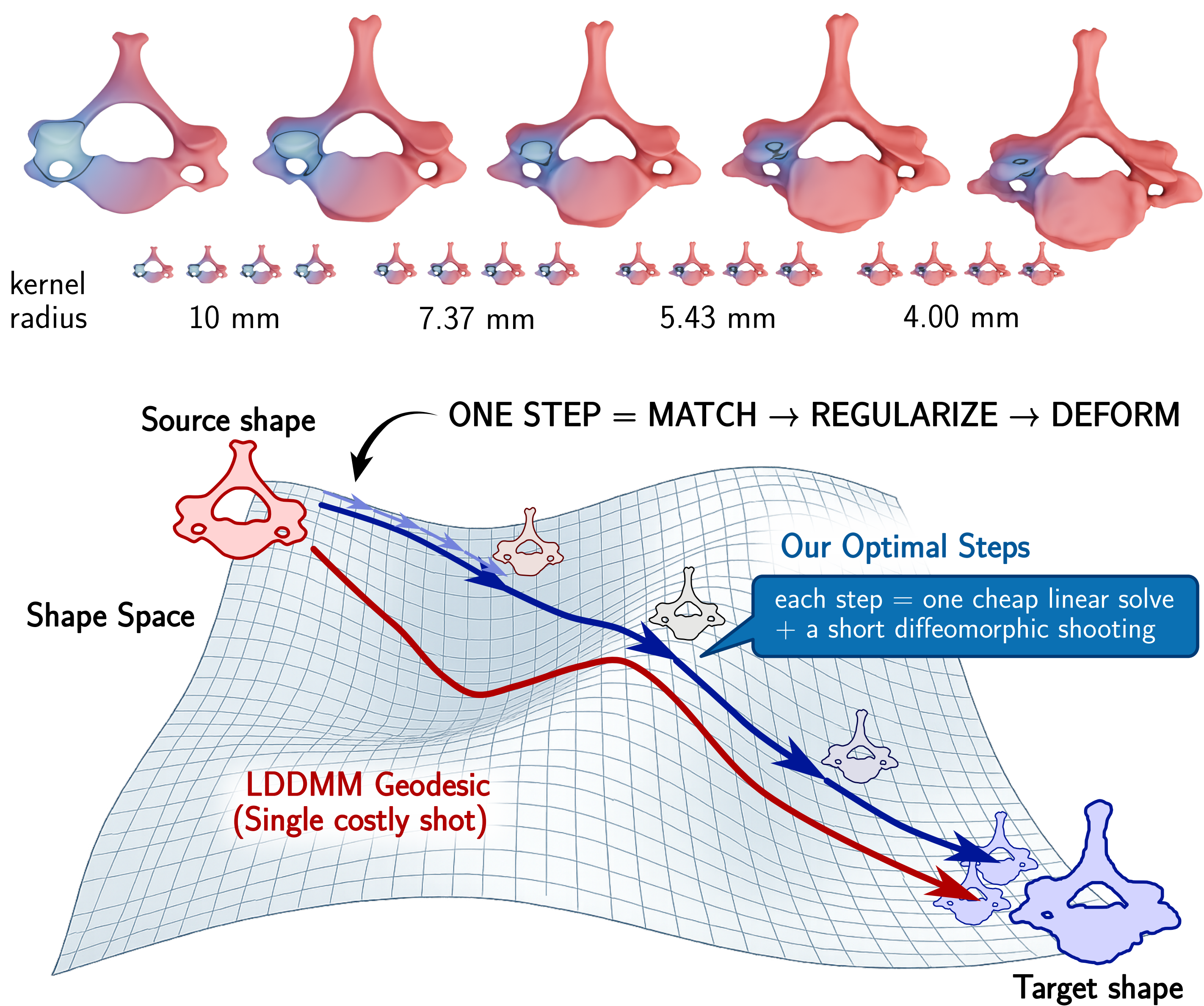
### Optimization-based



### The gap we address



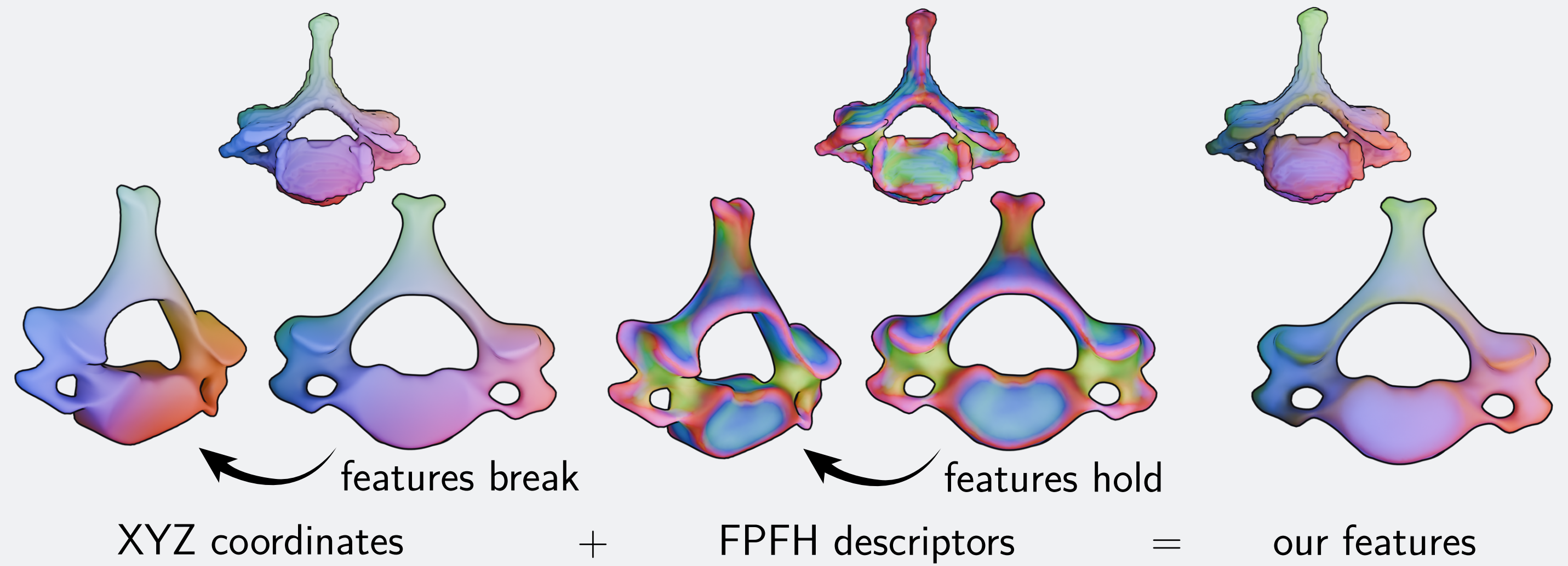
## OUR APPROACH AND INTUITION



We replace one expensive geodesic optimization by a sequence of cheap, controlled diffeomorphic steps.

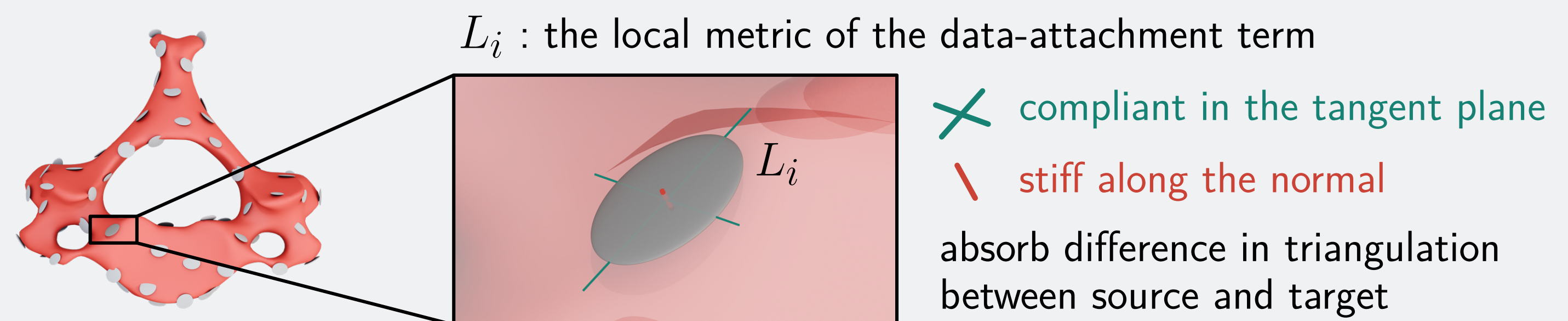
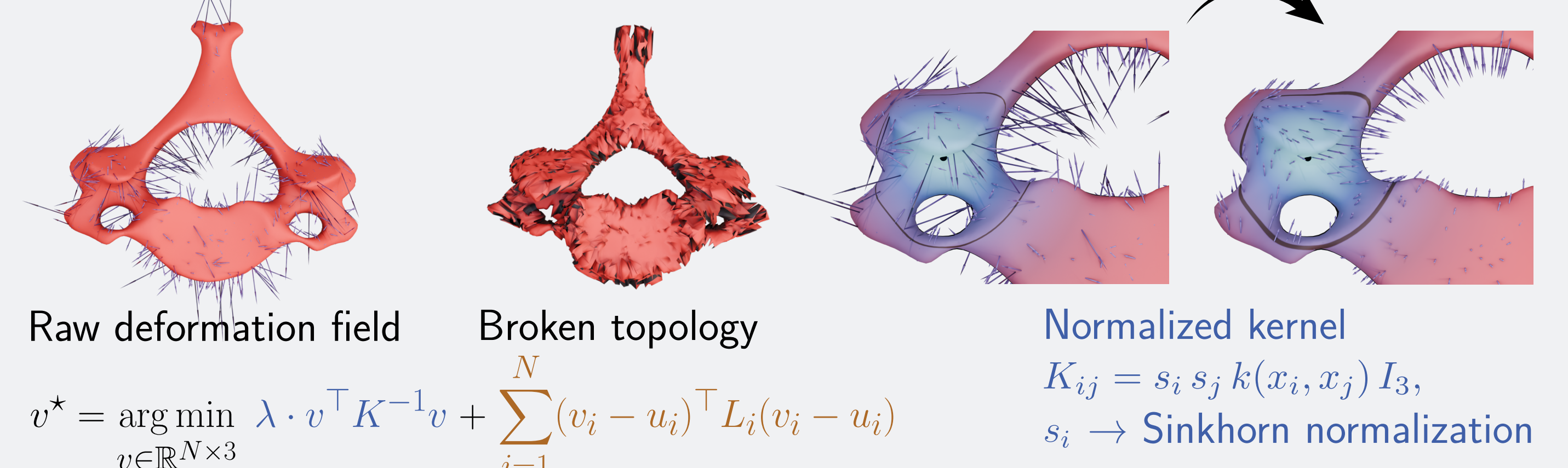
## ONE OPTIMAL STEP

### 1. MATCH Build robust correspondences



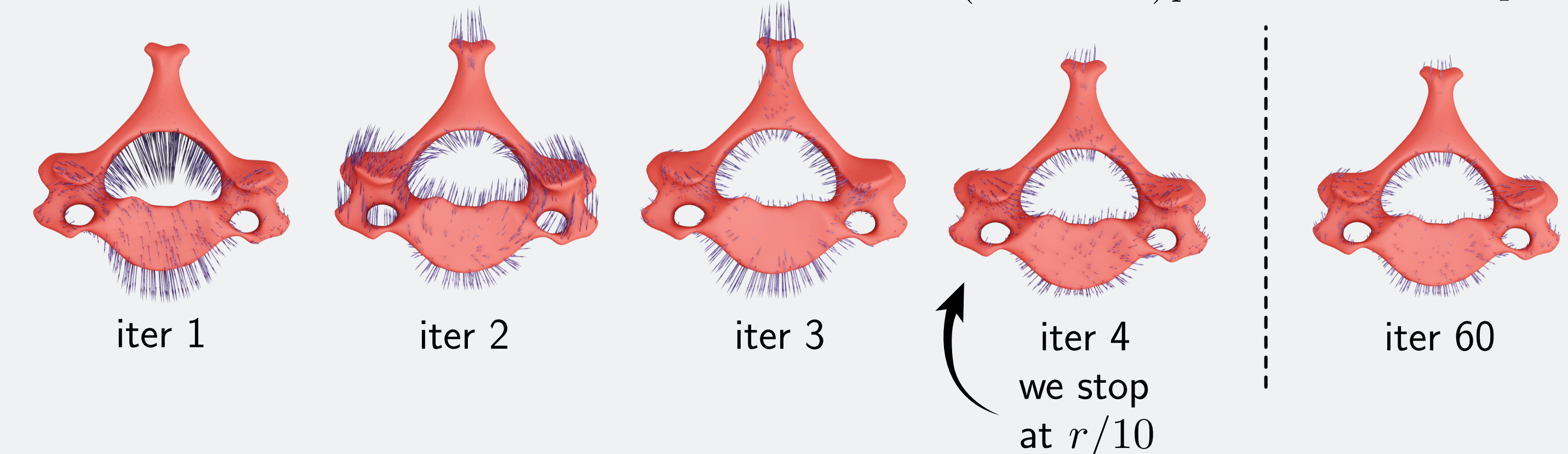
### 2. REGULARIZE

#### Prevent tearing and folding



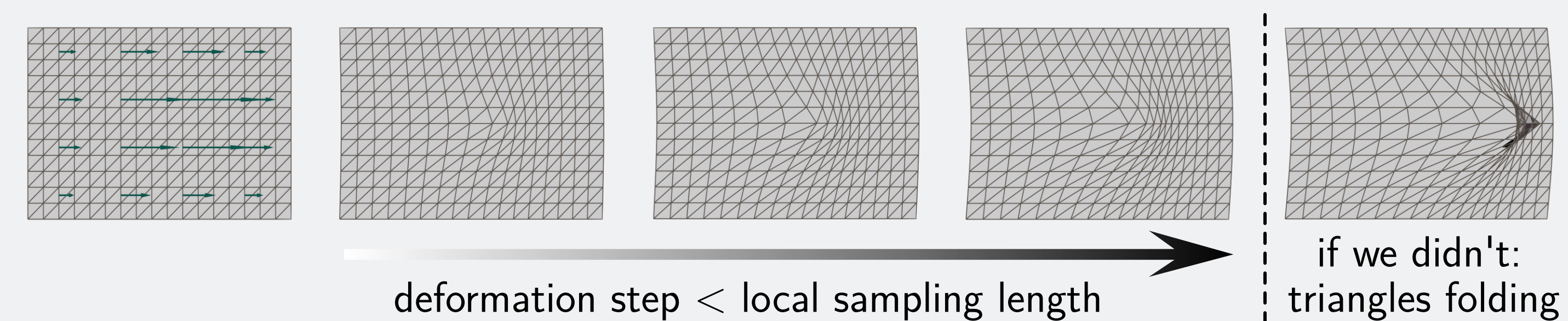
### SOLVE

#### One cheap linear solve per step

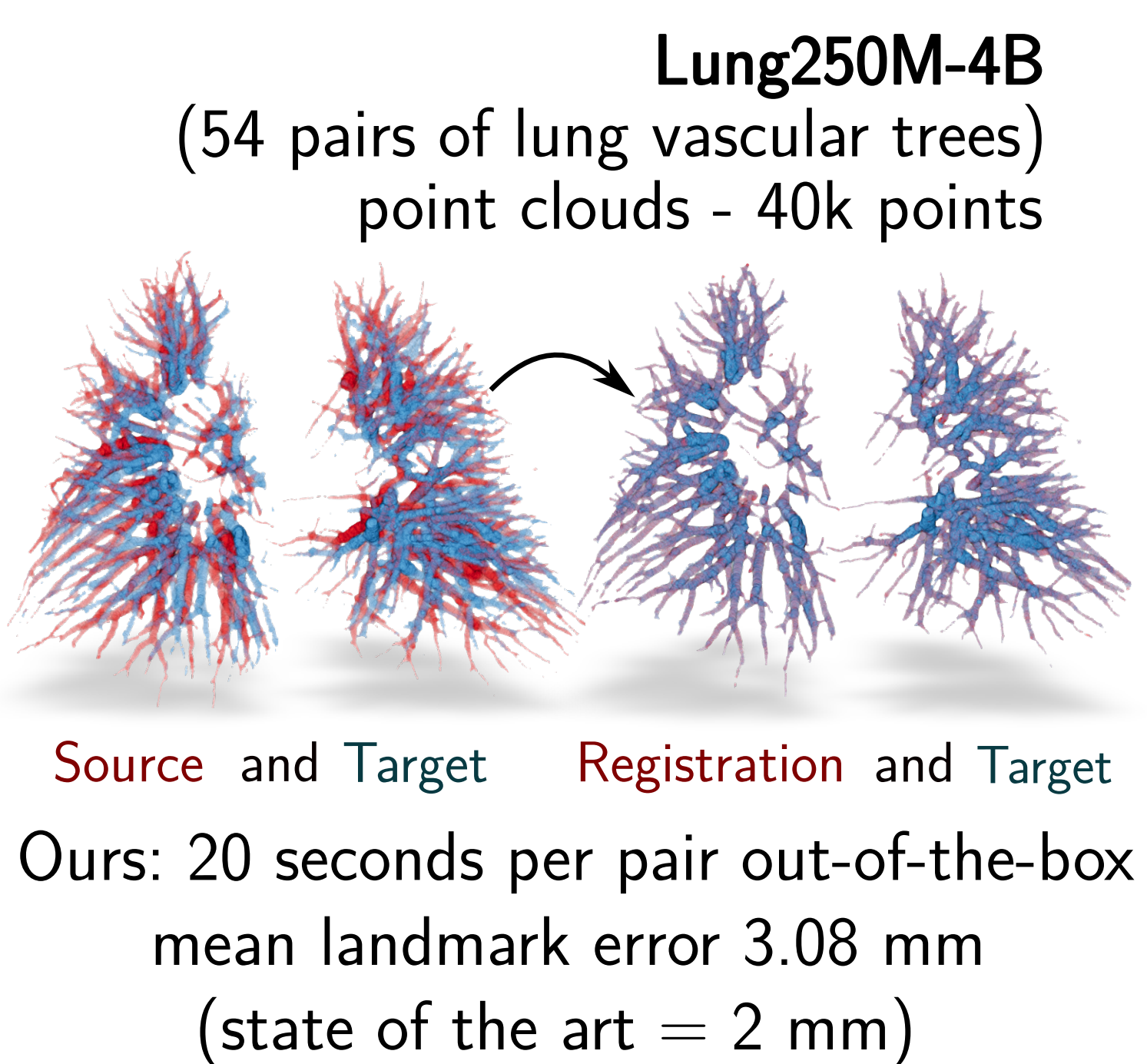


### 3. DEFORM

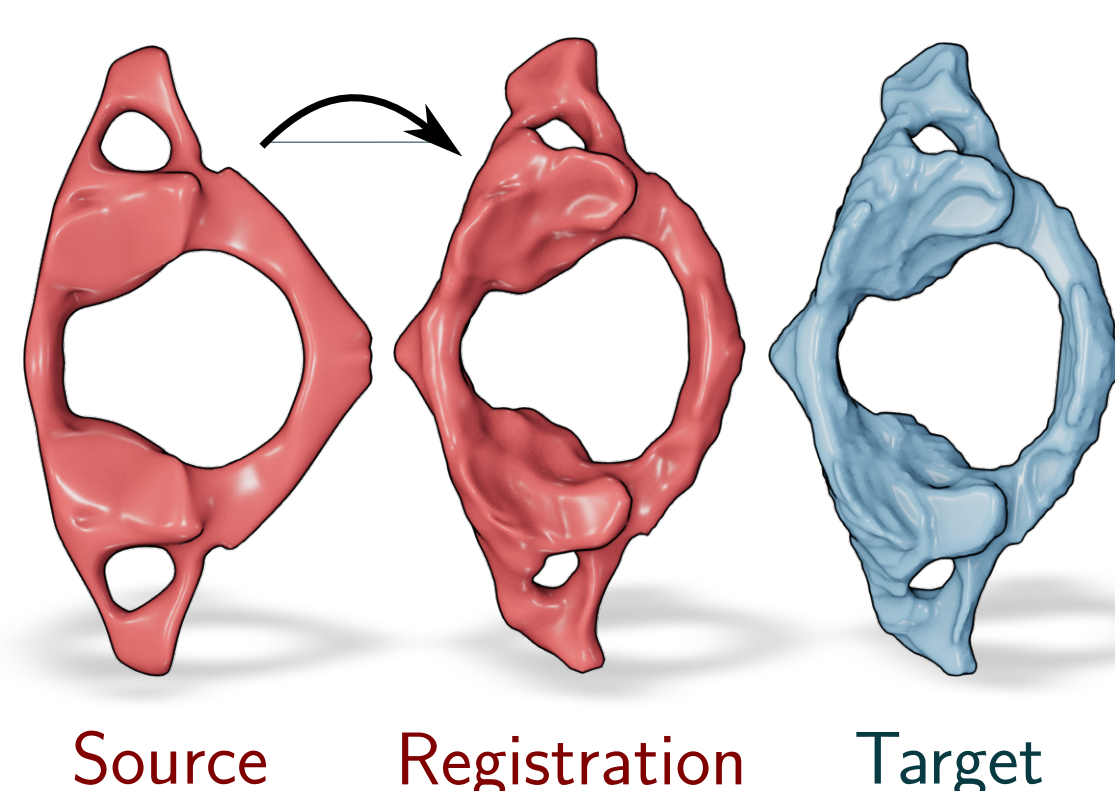
#### Apply the deformation field with an adaptive Euler step



## RESULTS (public benchmarks)



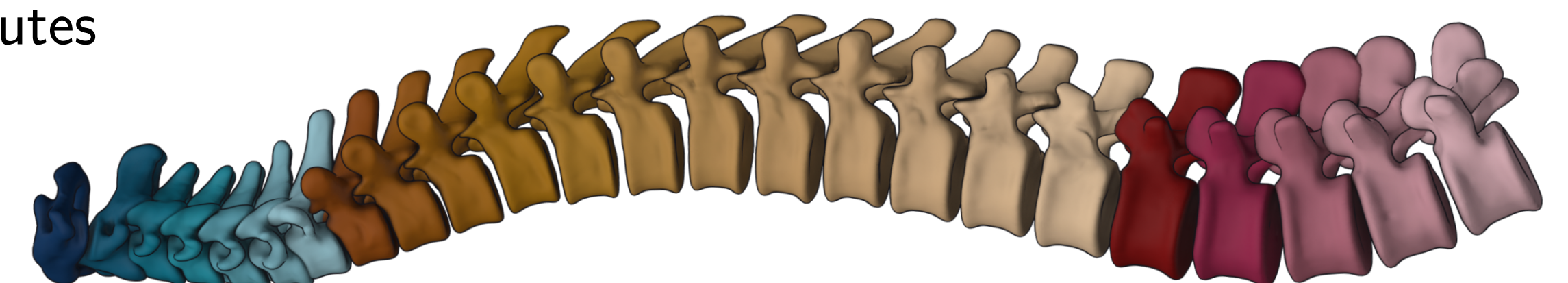
VerSe (757 test vertebrae) surface meshes · 10k points



| Method       | Chamfer (mm) ↓                    | HD95 (mm) ↓                       | Log-Jacobian Variance ↓           | Training Time ↓ | Inference Time ↓ |
|--------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------|------------------|
| VoxelMorph   | $2.39 \pm 1.20$                   | $7.68 \pm 4.58$                   | $0.12 \pm 0.10$                   | 46 min          | 15.2 ms          |
| Deformetrica | $0.24 \pm 0.12$                   | $0.74 \pm 1.61$                   | $0.38 \pm 0.47$                   | 0 s             | 43.5 s           |
| Ours         | <b><math>0.22 \pm 0.08</math></b> | <b><math>0.64 \pm 0.40</math></b> | <b><math>0.16 \pm 0.14</math></b> | <b>0 s</b>      | <b>1.05 s</b>    |

Atlas (mean vertebrae) built on the VerSe dataset.

757 vertebrae in 13 minutes on a single workstation.



## MAIN TAKEAWAYS

SHAPE AGNOSTIC & TRAINING-FREE

40× FASTER THAN DEFORMETRICA

DIFFEOMORPHIC & ROBUST



Explore results, animations and code!

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