Recent Advances in the Analysis of 3D Shapes

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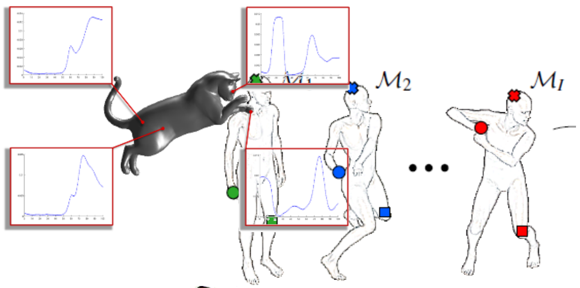


Get an overview on state of the art research in 3D shape analysis

Be able to read and understand scientific publications

Prepare and give a talk

Write a scientific report

Preparation

Please do not work on your topic completely alone

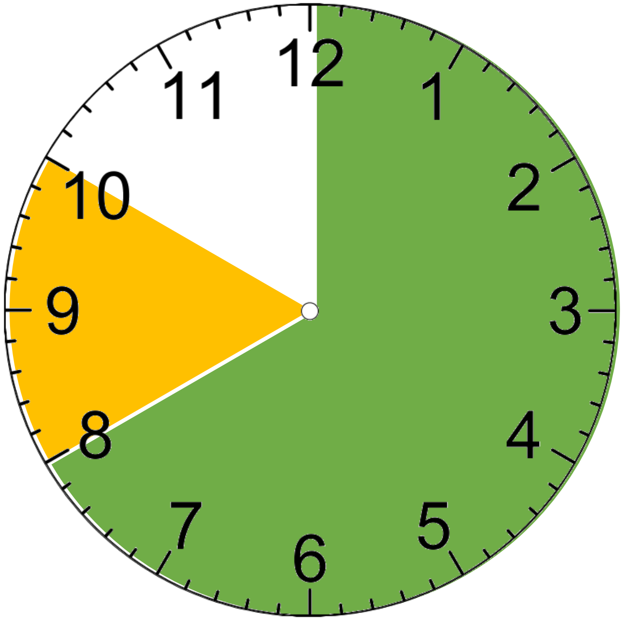
Meet at least twice with your supervisor

2 x

1 month

Deliver the report and discuss the slides with your supervisor

1 week



30 – 40 slides (ca. 1-2 minutes per slide)

Do not put too much information on the slides

Recommended structure

1. Introduction, problem motivation, outline
2. Approach

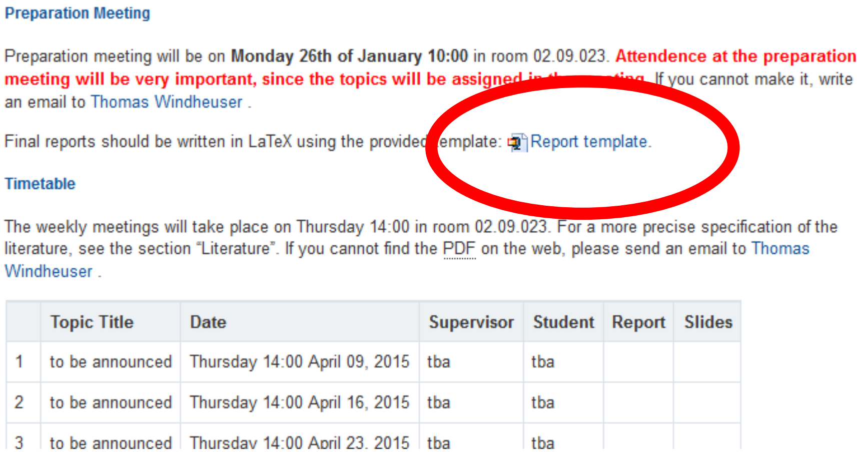
[3. Experimental Results]

4. Discussion
5. Summary (of scientific contributions)

Overview and main contributions of the assigned topic

6-10 pages

Latex template available on the web page



Preparation Meeting

Preparation meeting will be on **Monday 26th of January 10:00** in room 02.09.023. **Attendence at the preparation meeting will be very important, since the topics will be assigned in the meeting.** If you cannot make it, write an email to Thomas Windheuser .

Final reports should be written in LaTeX using the provided template: Report template.

Timetable

The weekly meetings will take place on Thursday 14:00 in room 02.09.023. For a more precise specification of the literature, see the section "Literature". If you cannot find the PDF on the web, please send an email to Thomas Windheuser .

	Topic Title	Date	Supervisor	Student	Report	Slides
1	to be announced	Thursday 14:00 April 09, 2015	tba	tba		
2	to be announced	Thursday 14:00 April 16, 2015	tba	tba		
3	to be announced	Thursday 14:00 April 23, 2015	tba	tba		

Evaluation Criteria

Attendance at each appointment is necessary

Notice that many papers are not completely self-contained

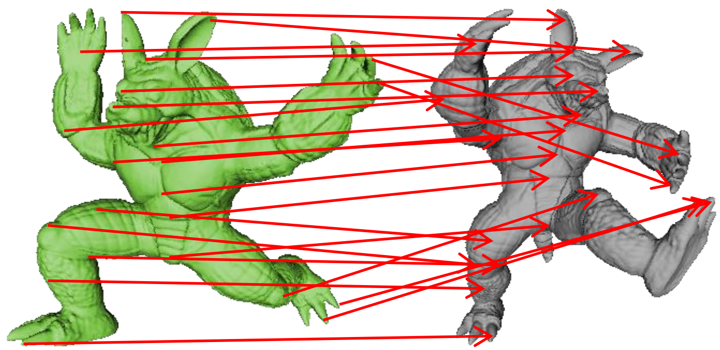
It may be important to check related articles or text books

Report should be more detailed than original paper

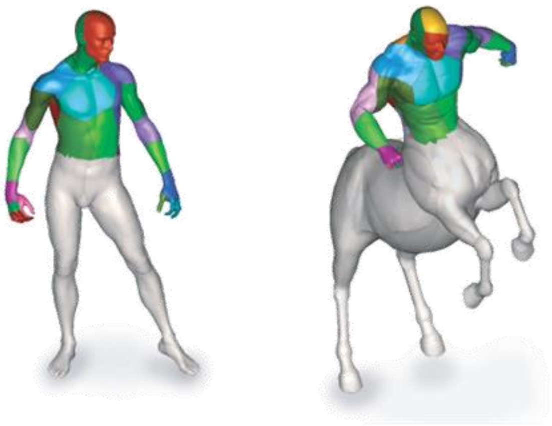
Own implementations and graphics (where feasible) are appreciated

Typical Problems in 3D shape analysis

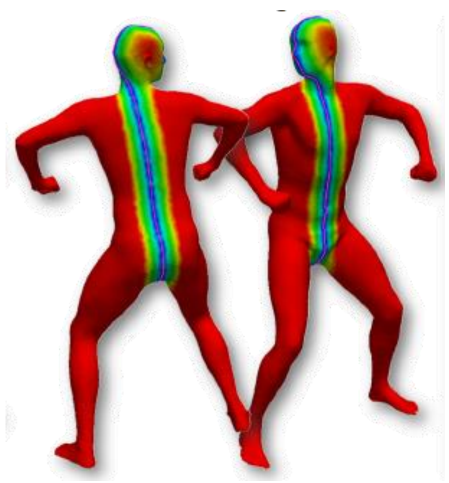
Typical problems



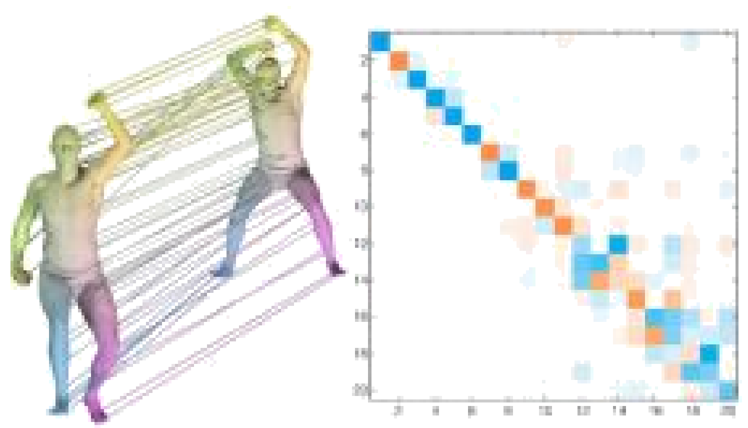
Correspondence



Partial similarity



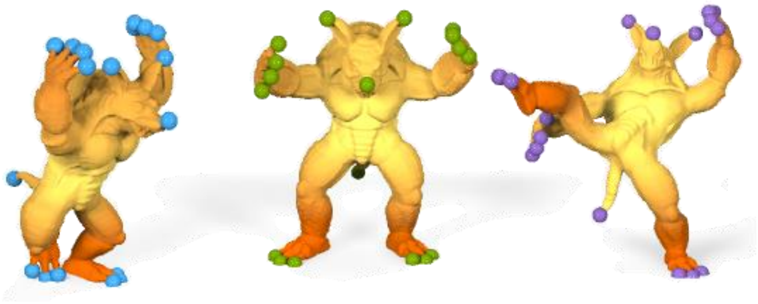
Symmetry



Representation

Typical problems

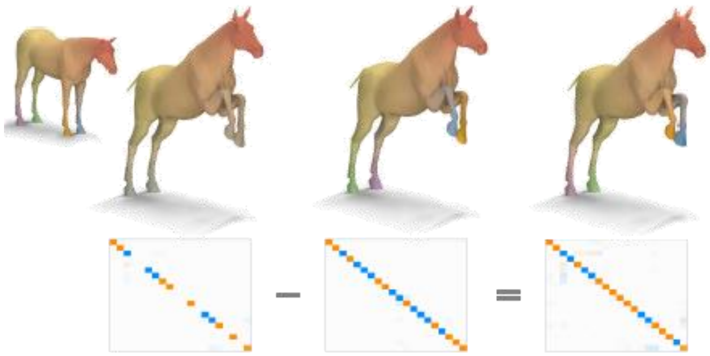
Analysis of shape collections



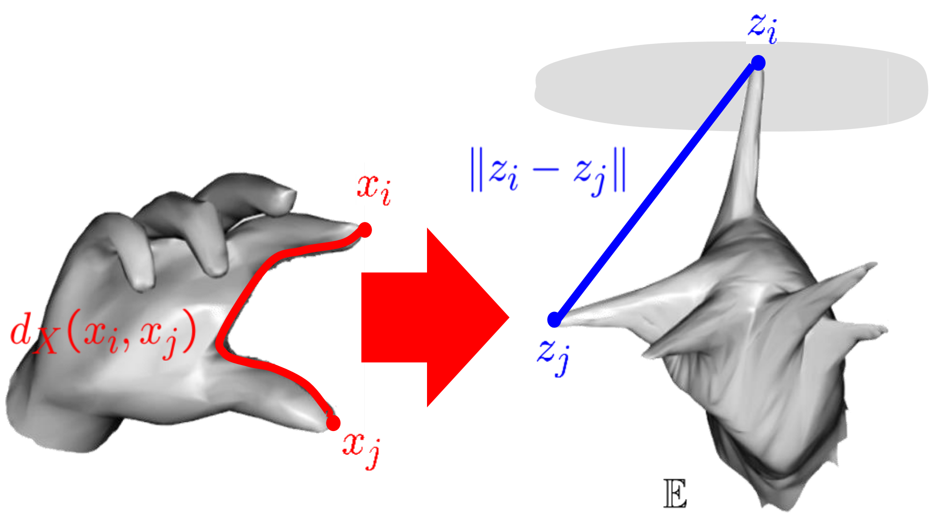
Feature detection

Segmentation

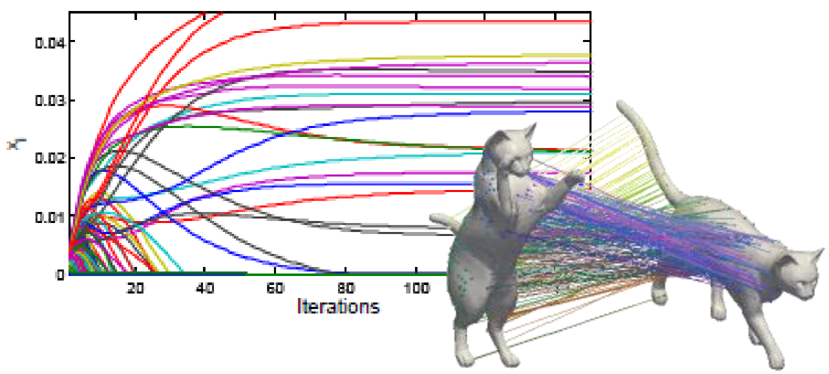
Description



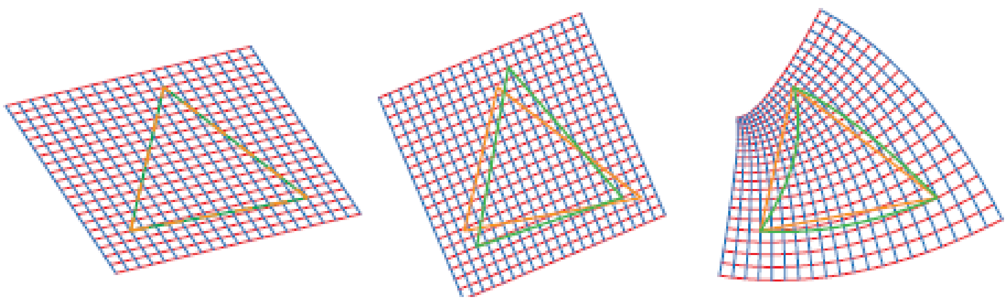
Linear algebra



Metric spaces



Optimization

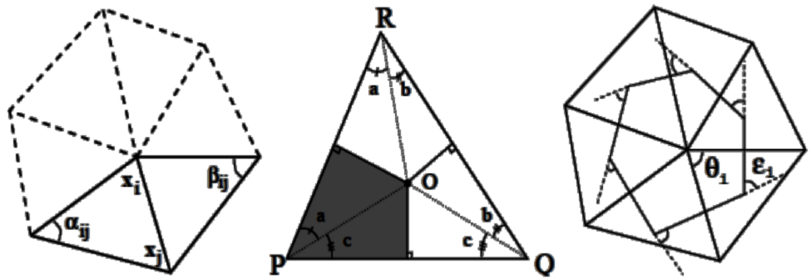


Differential geometry

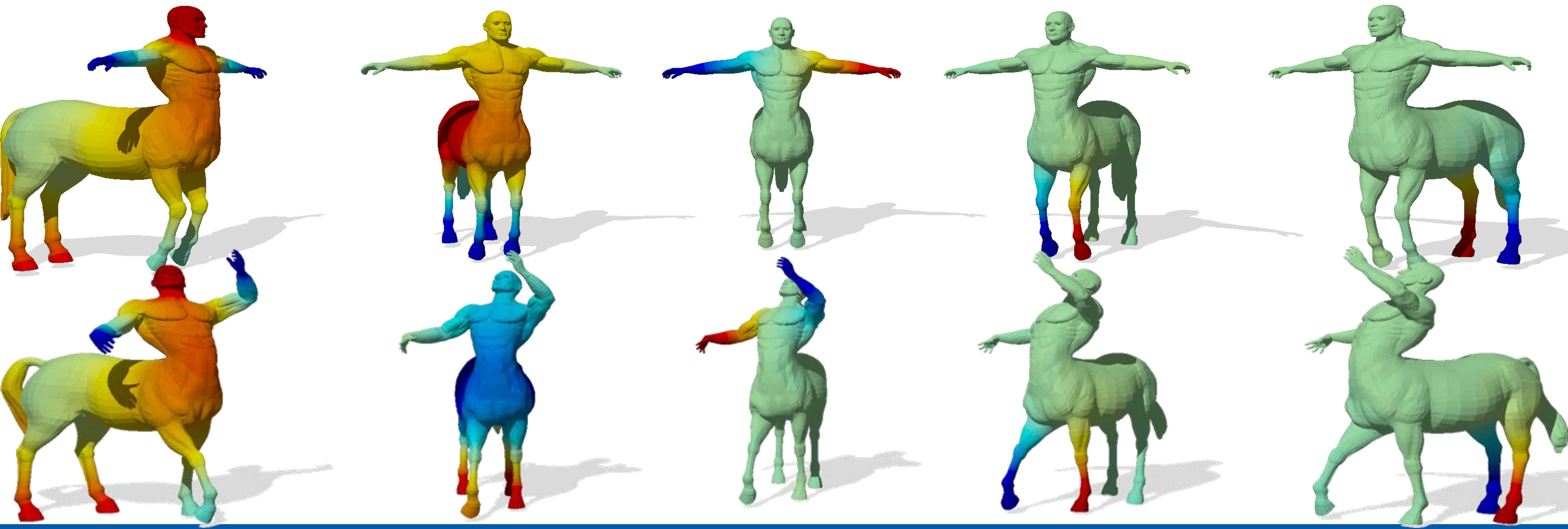
Overview of Available Topics

Laplace-Beltrami Operator

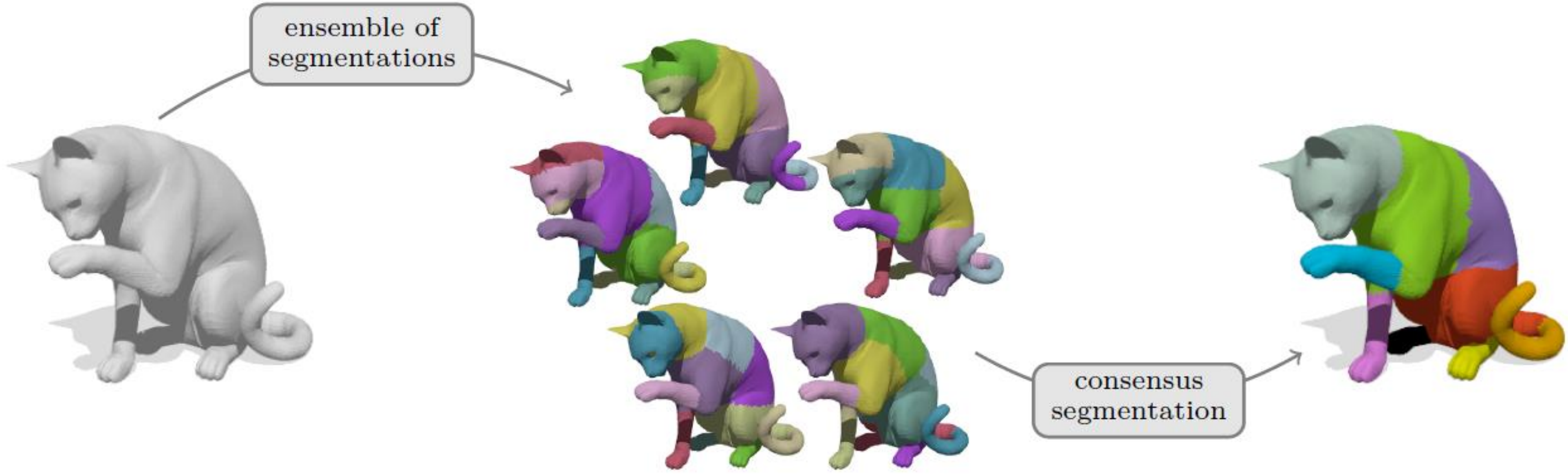
- One of the key tools for 3D shape analysis
- Mathematical Background and Discretizations



- Two talks

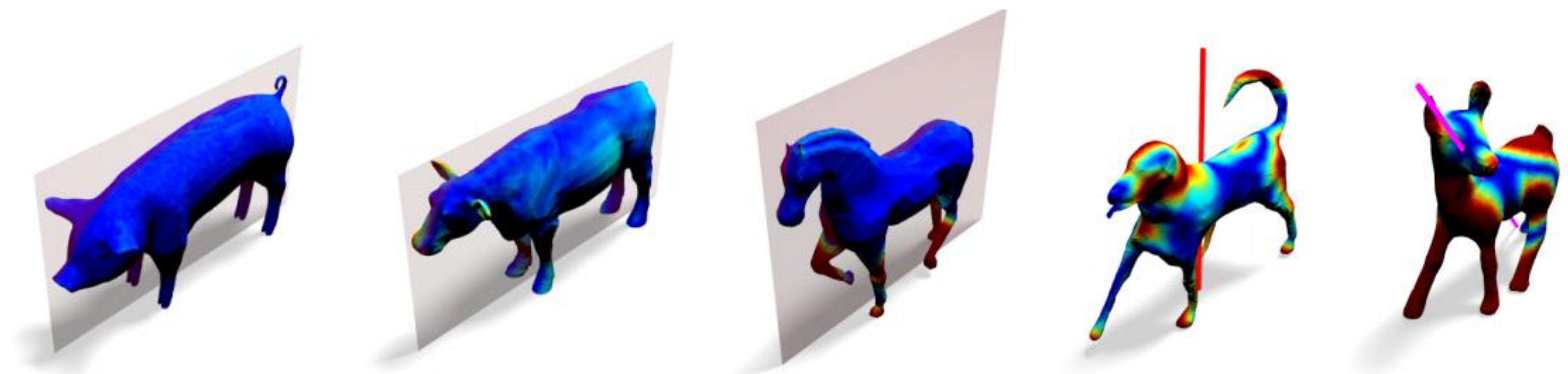


- Detection of regions that are stable under many deformations
- Semantically meaningful segmentation
- Based on unsupervised learning



Probably approximately symmetric: Fast rigid symmetry detection with global guarantees

- Global symmetry detection in 3D shapes
- Theoretical guarantees to find the best (approximate) symmetry
- Uses a volumetric representation of the shapes

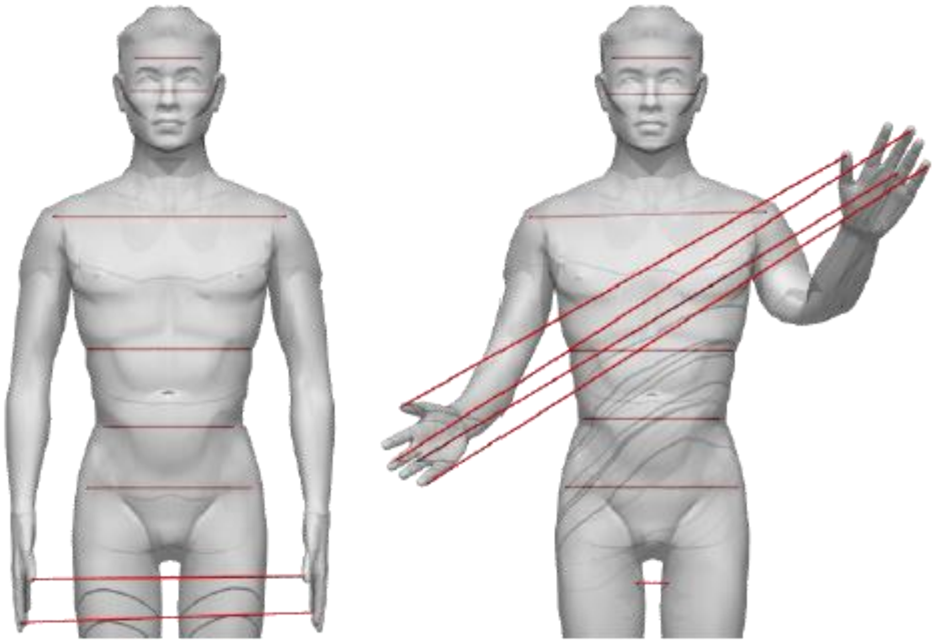


reflection (0.0068) reflection (0.0282) reflection (0.0496) 2-fold (0.1004) axial (0.1686)

Global intrinsic symmetries of shapes

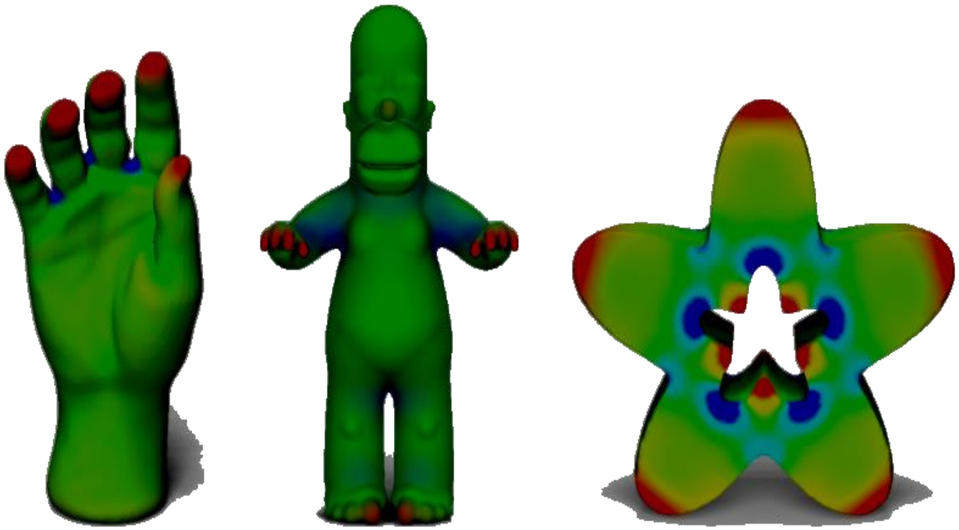
- Global symmetry detection when the shapes are allowed to deform
- Based on properties of the Laplace-Beltrami operator
- Formulated as a matching problem

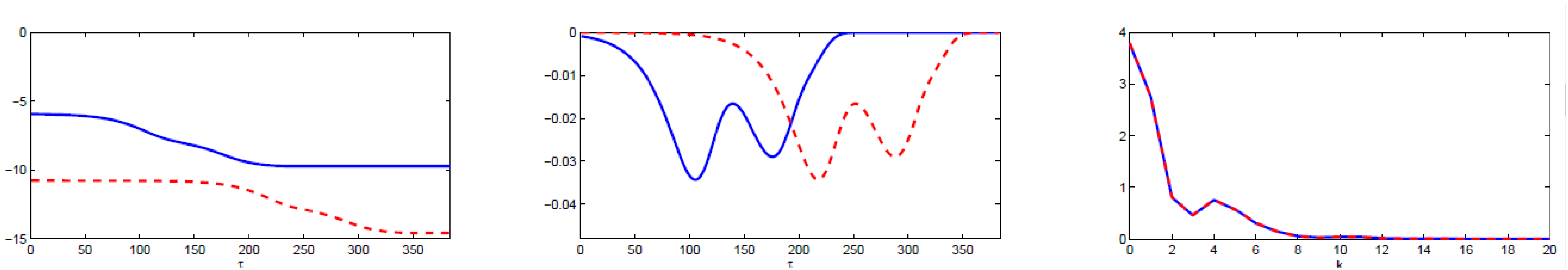
  between the shape and itself



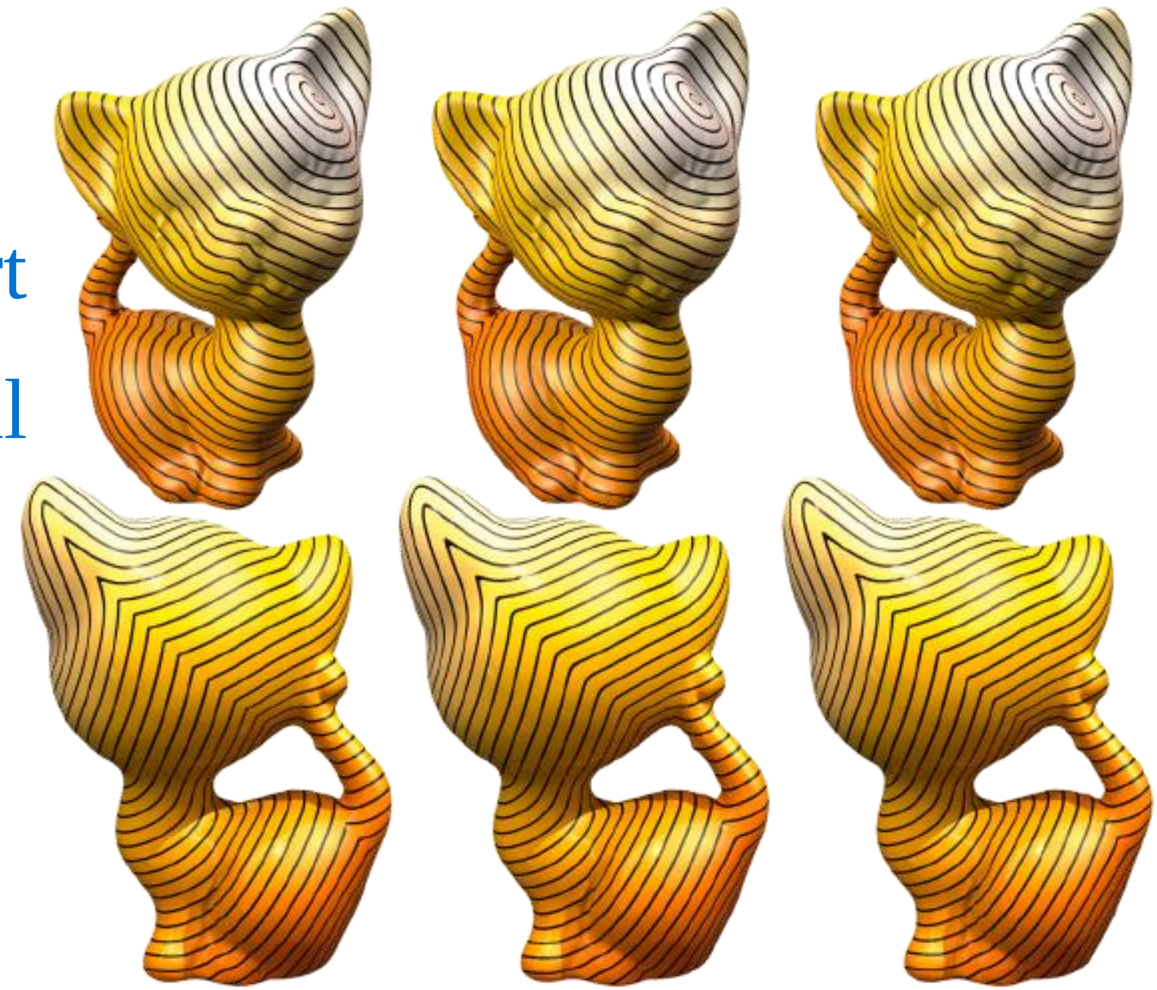
Scale-invariant heat kernel signatures for non-rigid shape recognition

- Pointwise feature descriptor
- Invariant to big class of deformations
- Based on heat diffusion and Fourier transform of the descriptor space



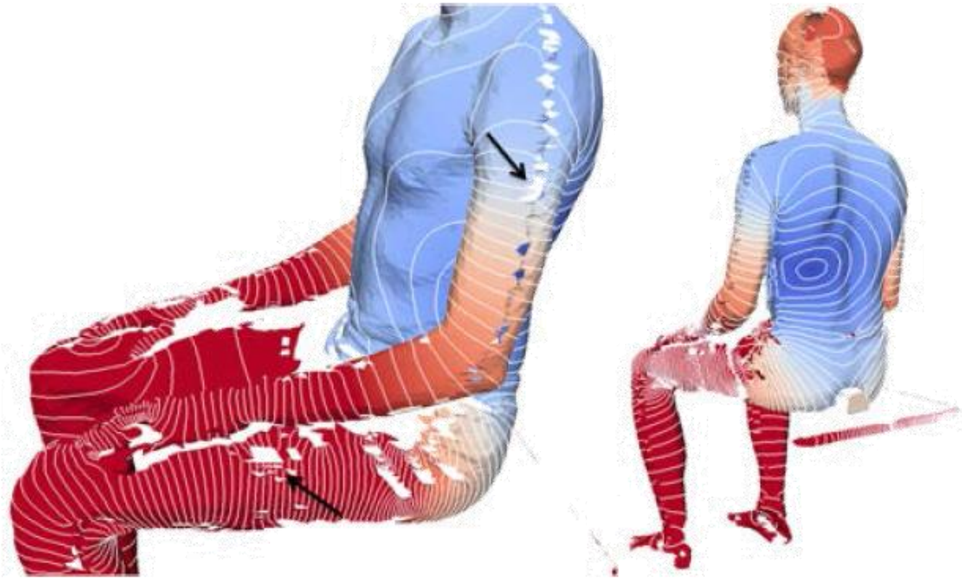


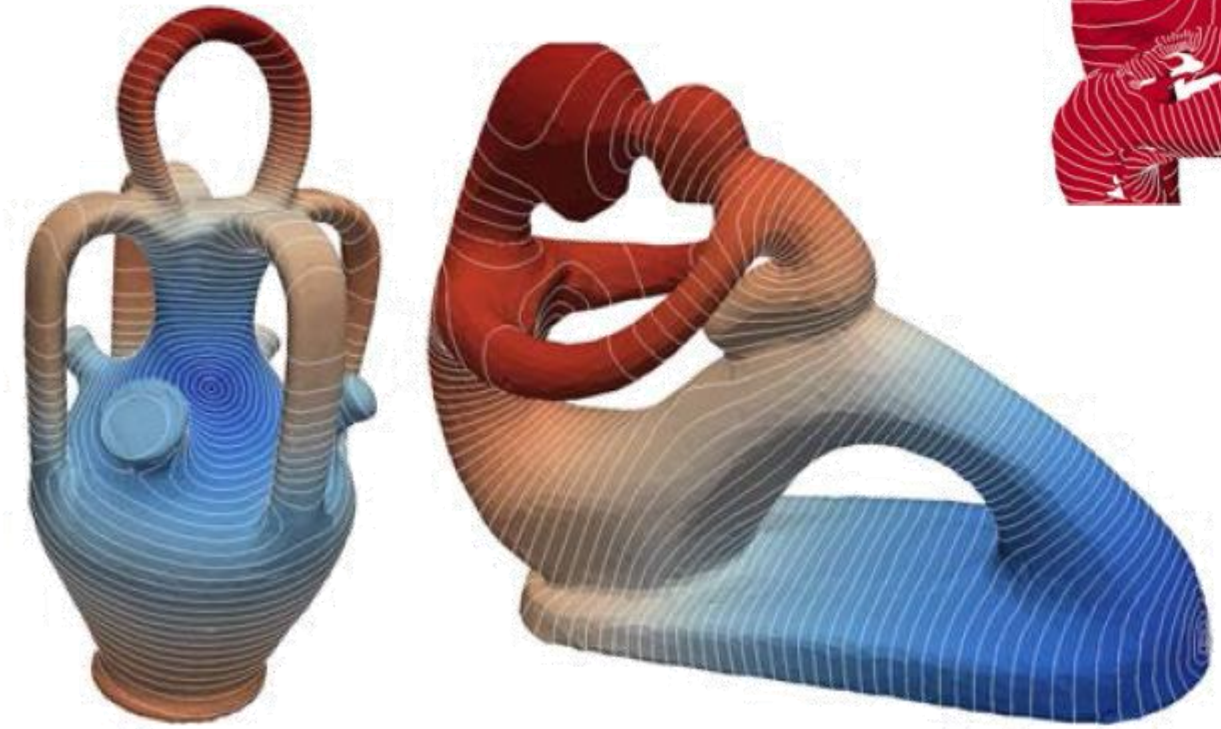
- A method to compute geodesic distances based on heat diffusion
- An order of magnitude faster than state of the art
- Applicable to polygonal meshes, point clouds, as well as other representations



Biharmonic Distance

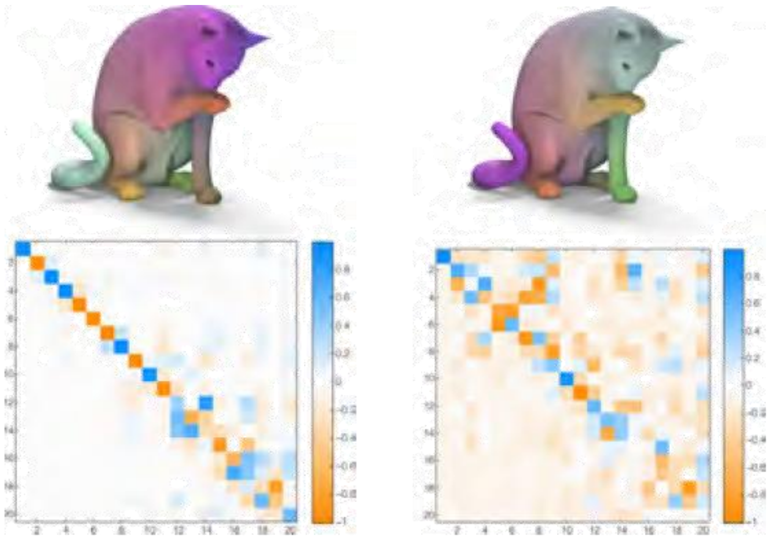
- Intrinsic metric (distance function)
- More robust to noise than geodesic distance

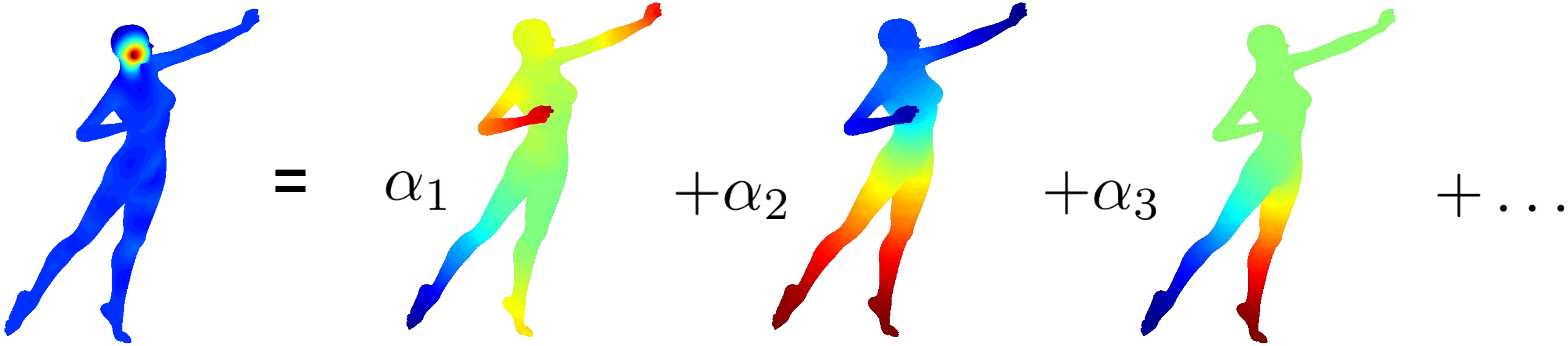




Functional Maps: A Flexible Representation of Maps Between Shapes

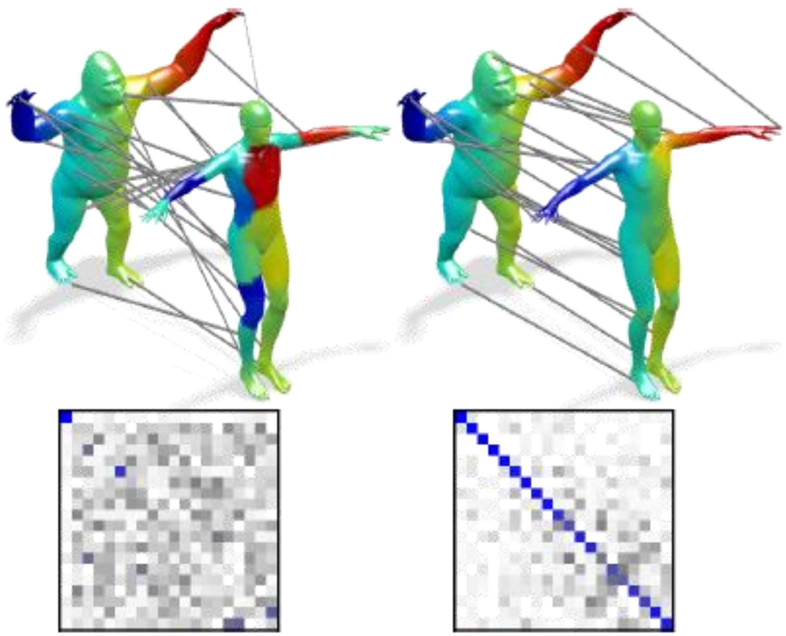
- Consider correspondences as linear operators
- Compact representation
- Related to Fourier analysis on manifolds





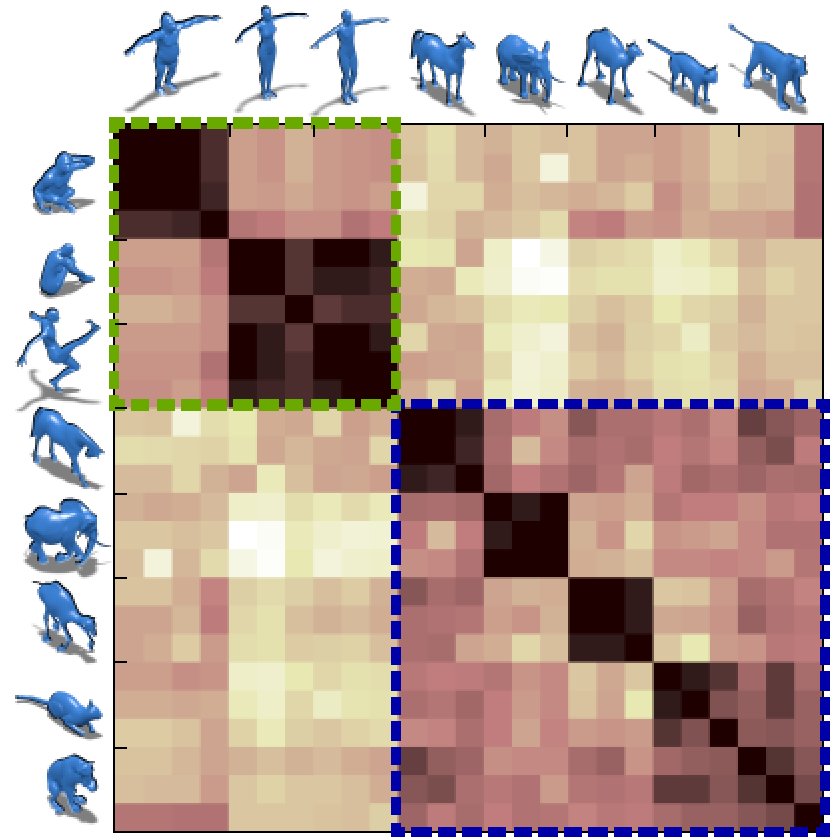
Coupled quasi-harmonic bases

- Interclass matching
- Learning the “best” functional bases for a given pair of shapes



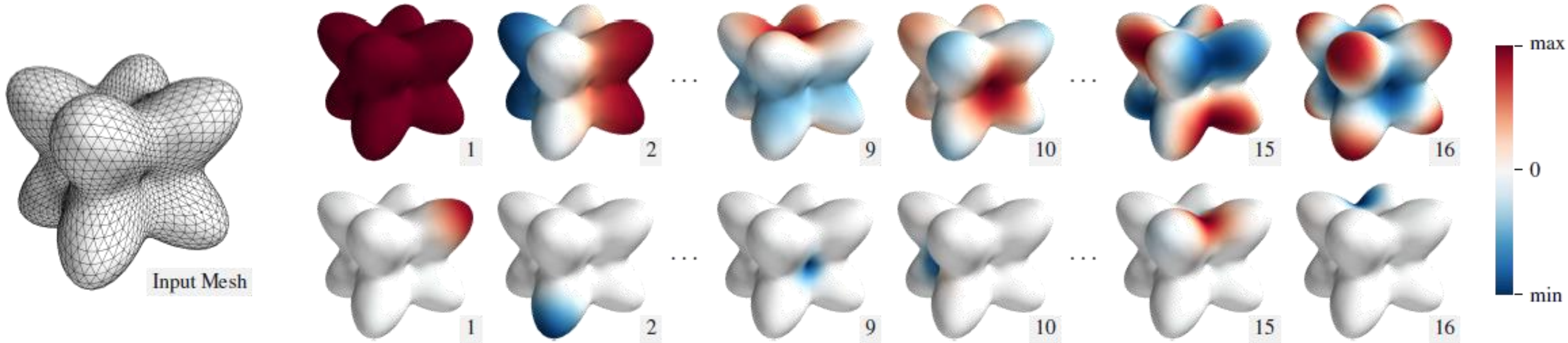
Eigenbases, full matrix

Coupled bases, diagonal only

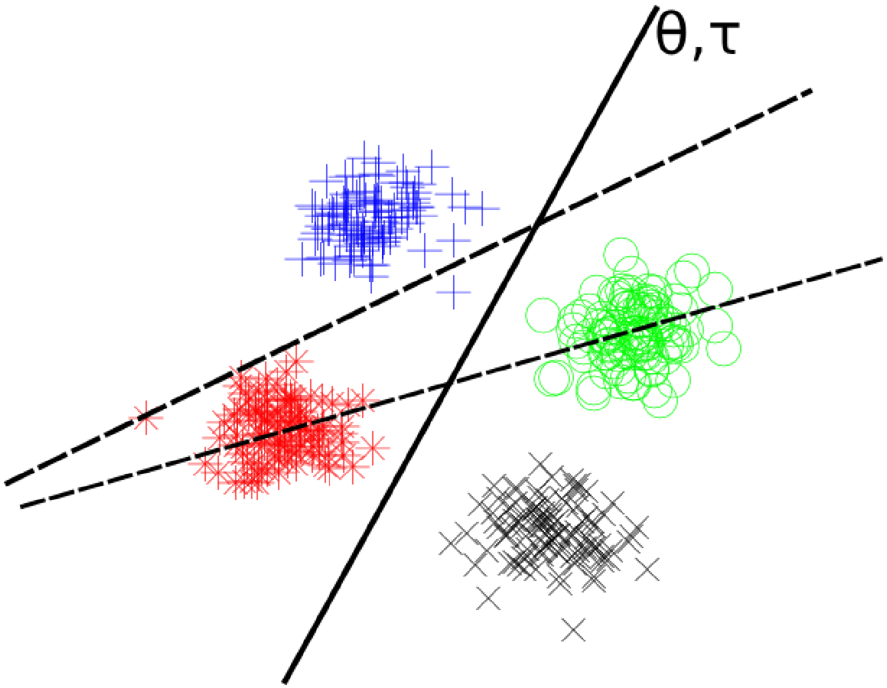


Compressed manifold modes for mesh processing

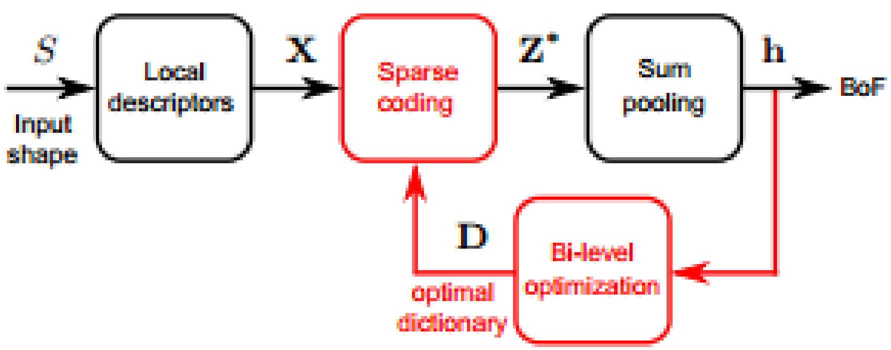
- Locally supported quasi-harmonic bases
- Allows to identify key features of the shape
- Shapes as collections of parts
- Enables several applications (segmentation, etc.)



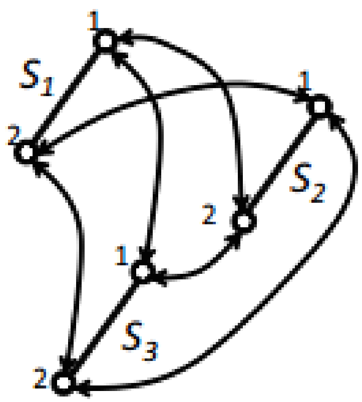
- Apply random forests to perform shape matching
- Allows faster matching times
- General framework for inter-class matching

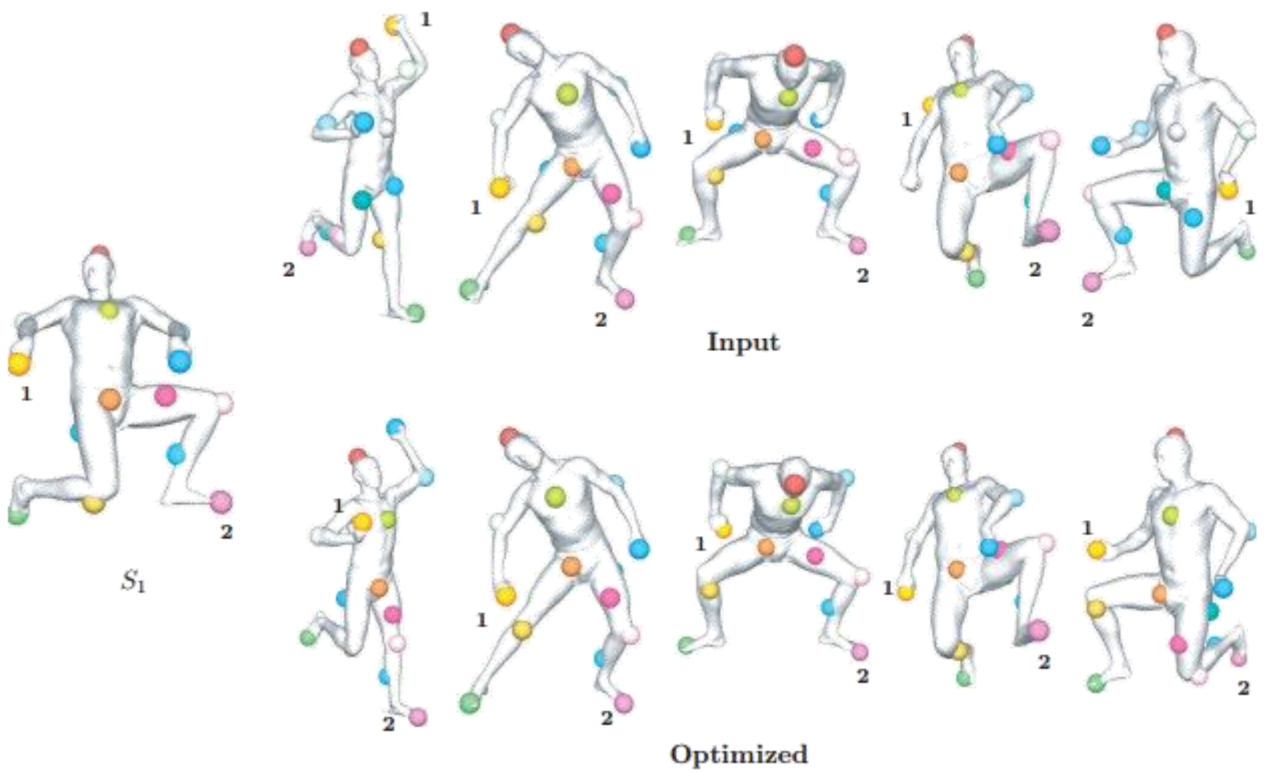


- Dictionary learning for shape retrieval (supervised learning)
- Provides a global shape descriptor that is fast to evaluate and compare
- State of the art retrieval

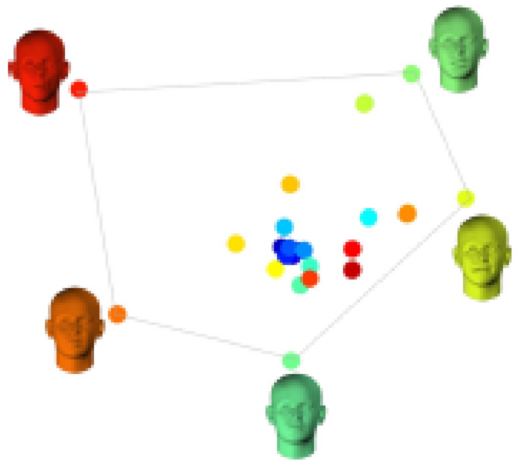


- Analysis of shape collections
- Consistently matching all shapes in a given collection starting from input maps
- Theoretical guarantees in presence of noisy input





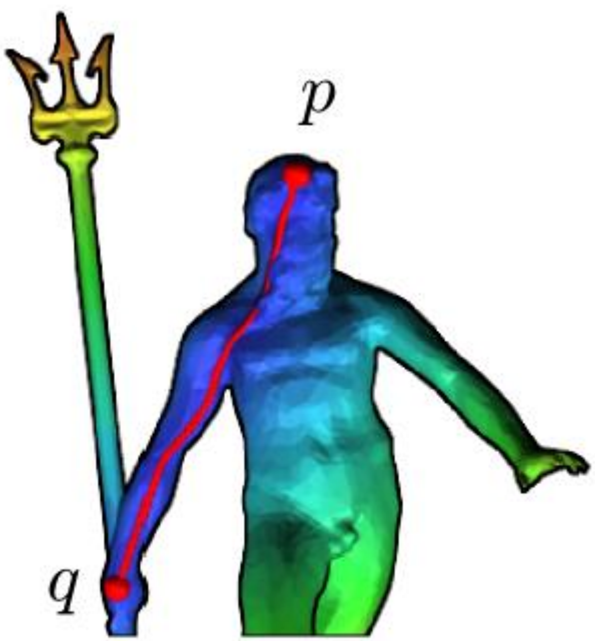
- Analysis of shape collections
- Given two shape collections with similar structure, match the two collections
- Uses functional maps

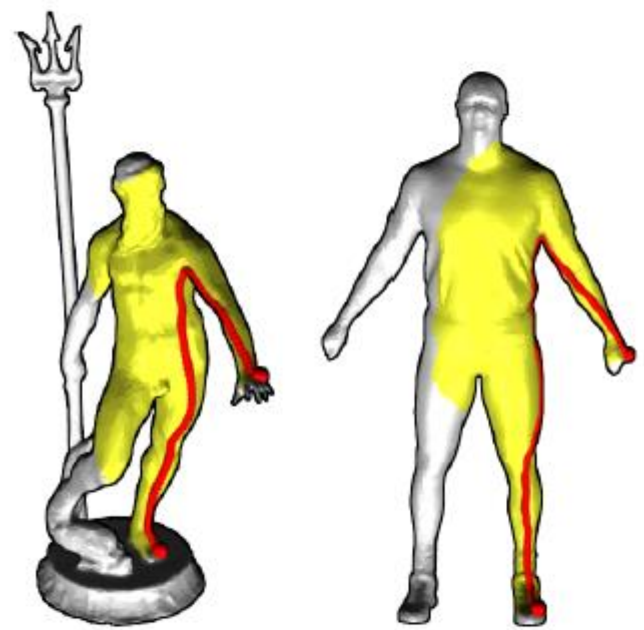


(a) (b) (c)

Bilateral Maps for Partial Matching

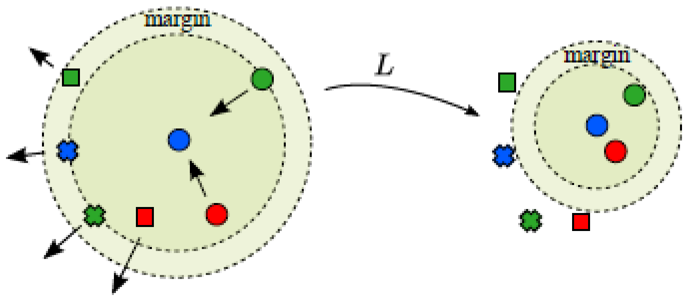
- Define shape descriptors for pairs of points instead of individual points
- Allows to do partial matching
- Robustness to topological changes

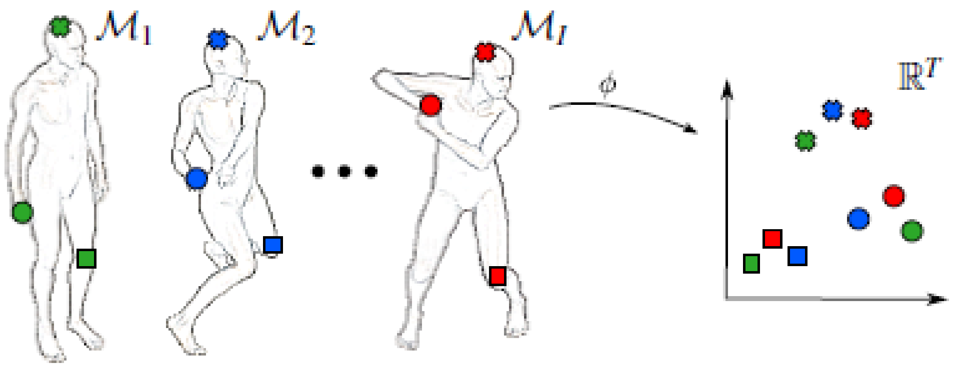




Optimal Intrinsic Descriptors for Non-Rigid Shape Analysis

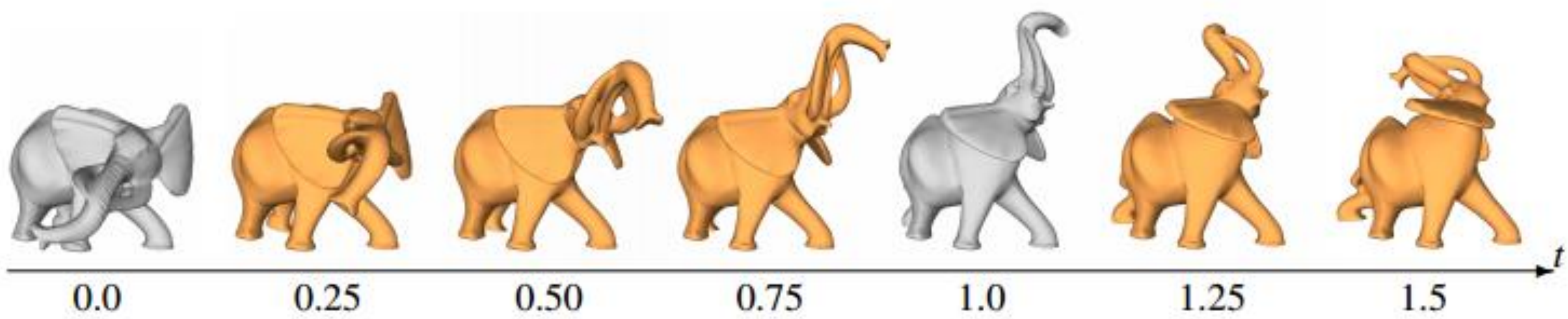
- Supervised learning of optimal point descriptor
- Optimizing in infinite-dimensional space
- Best possible parametrization for existing descriptors





Exploring the geometry of the space of shells

- Shapes as points in a "space of shapes"
- Geodesics in this space correspond to deformations between shapes
- Possible to interpolate / extrapolate shapes by walking on geodesics



- Partial isometric matching
- Matching points and local coordinate system
- Robust to topological noise
- State of the art on real world data