

Project Topics

COMP0119 2023-2024

What we covered in class?



Introduction

1. Applications
2. Surface representations

Basic Geometry Acquisition and Registration

1. 3D acquisition using laser scanners + SfM
2. Local registration (ICP and variants)

Geometry Acquisition and Registration

1. Advanced registration (branch-and-bound, ICP variants)
2. Introduction to surface stitching

Differential Geometry

1. Introduction to curves and surface
2. Mesh quality measures

Parameterization

Remeshing

Simplification

Mesh Deformation and Animation

Logistics

- Project assignment
(please pick only one topic; either the same as last time or one of the other listed topics)
- Start by picking/reading and understanding **relevant paper(s)**
~ 10pt for paper summary and criticism + report
- Get **data + libraries (please acknowledge, i.e., provide citation and/or links)**
- You are working individually for the resit project.
- 40% of total course grades (40pts out of 100pts);
paper summary + report (10pts); paper implementation(10-15pts);
extension/novelty (5-10pts); evaluation (10pts)
- Submission: **consult the admin team**

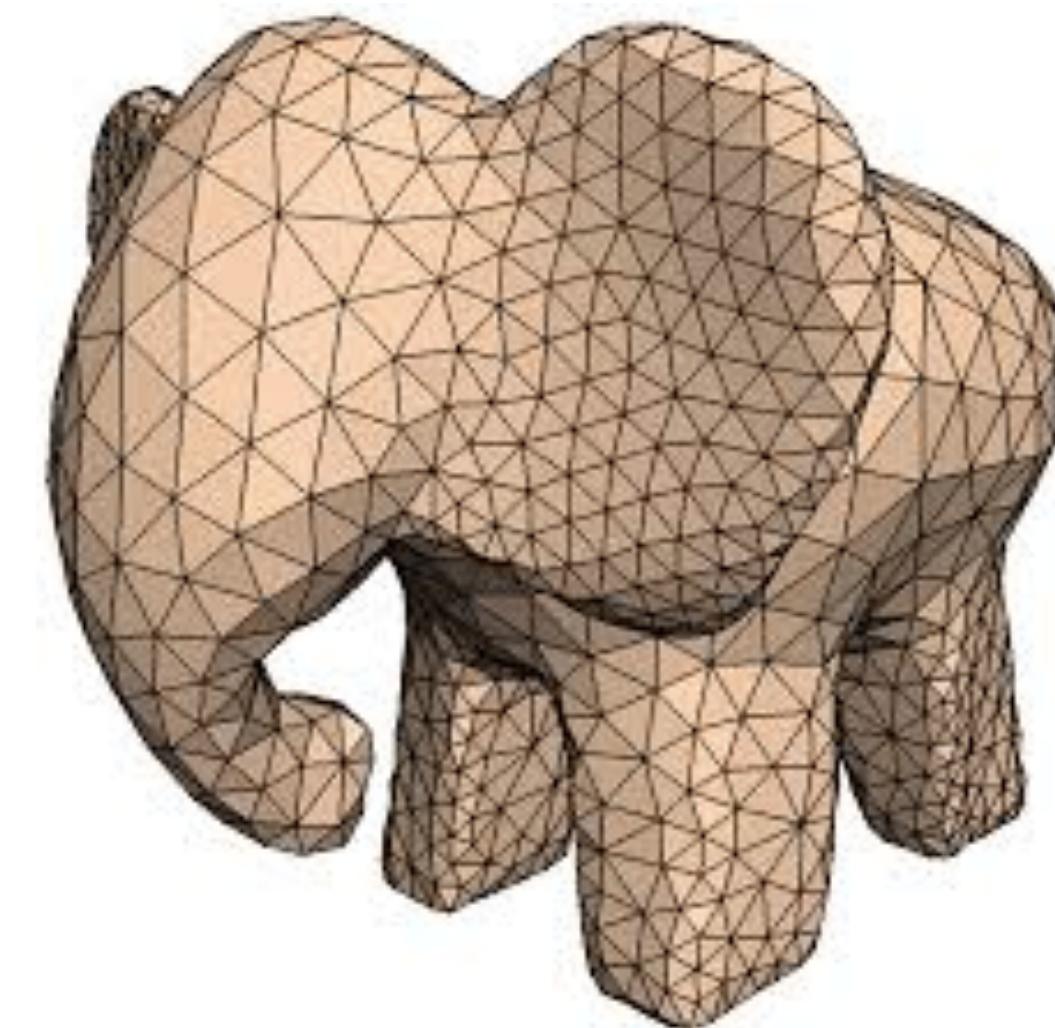
1. Simultaneous Registration

- ICP
- skill set:
 - gathering data
 - using libraries (for optimization)
 - Image features
https://huggingface.co/docs/transformers/model_doc/vit

paper: [https://www.sciencedirect.com/science/article/pii/S1077314200908841?
via%3Dhub](https://www.sciencedirect.com/science/article/pii/S1077314200908841?via%3Dhub)

2. Remeshing

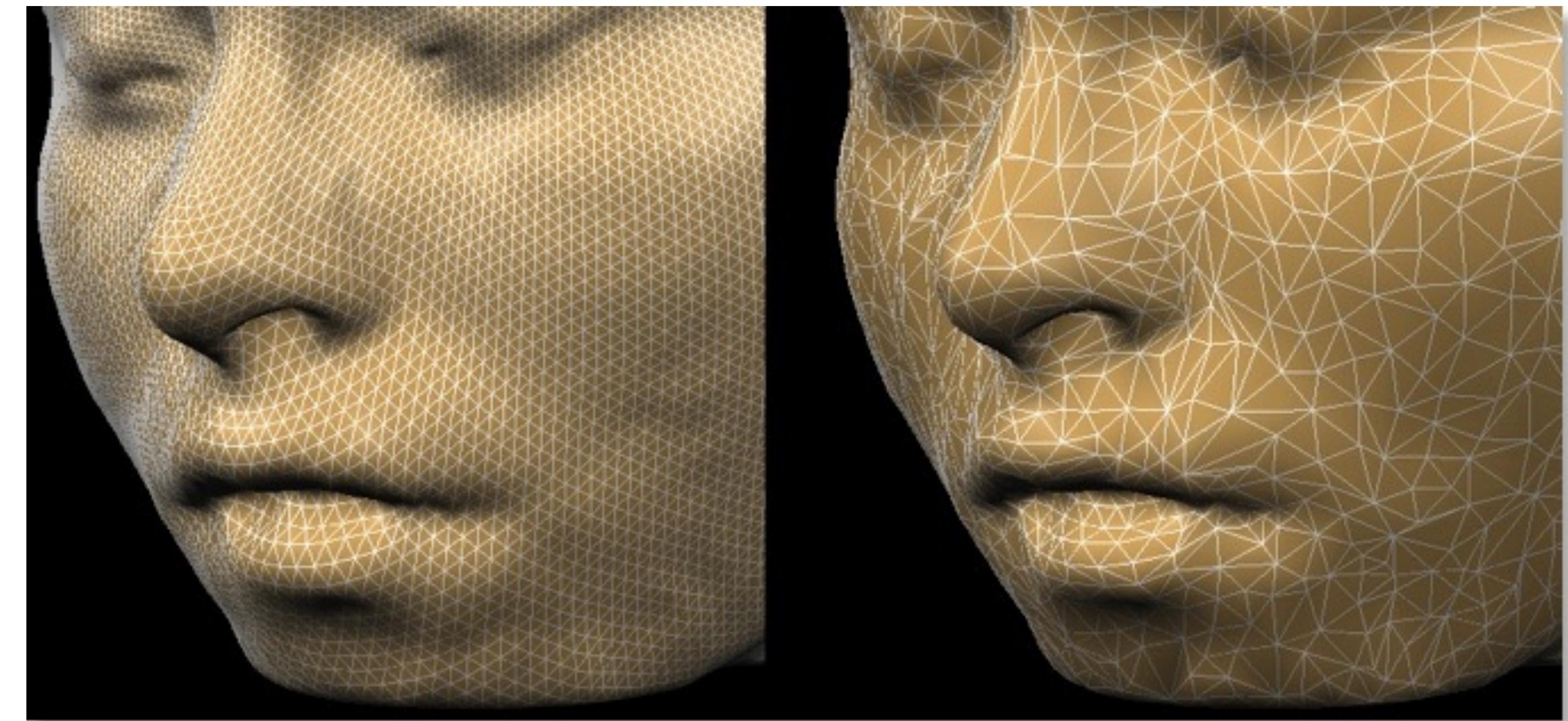
- Assume access to **parameterization** (tools available) or **surface-based**
- CVT based relaxation (as studied in class)
- skill set:
 - getting to run CGAL (library)
or implement uniform sampling in 2D
 - basic mesh manipulation



paper: see class notes

3. Mesh Simplification

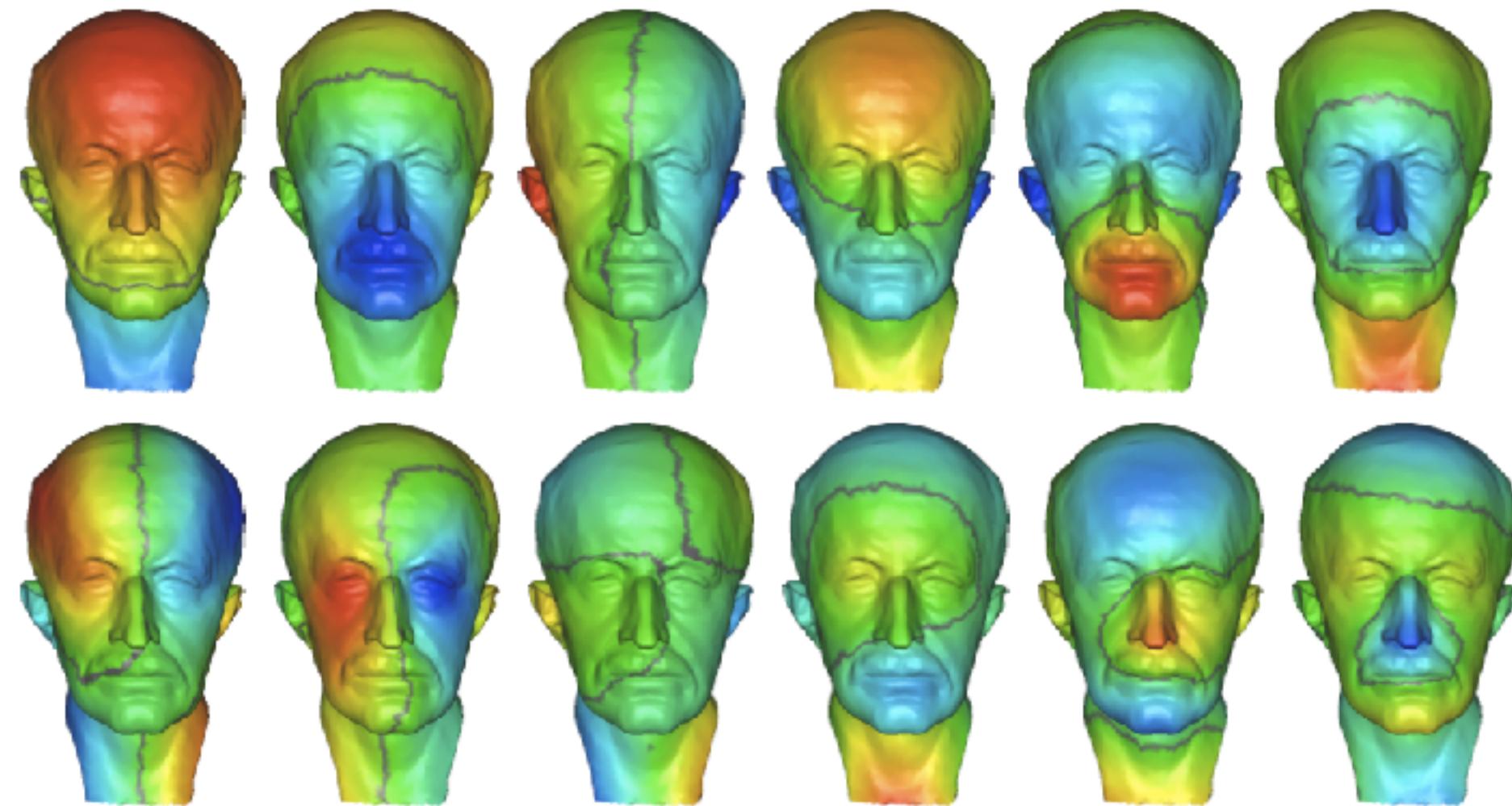
- Using error quadric
- Extensions based on progress
- skill set:
 - simple project
 - basic linear algebra



paper: Surface Simplification Using Quadric Error Metrics
M. Garland and P. Heckbert, SIGGRAPH 97

4. Mesh-manipulation with Spectral Mesh Processing

- construct basis for meshes
- manipulate them by changing basis coefficients
- skill set:
 - simple UI
 - efficient eigen decomposition (sparse solver)



paper: see class notes +

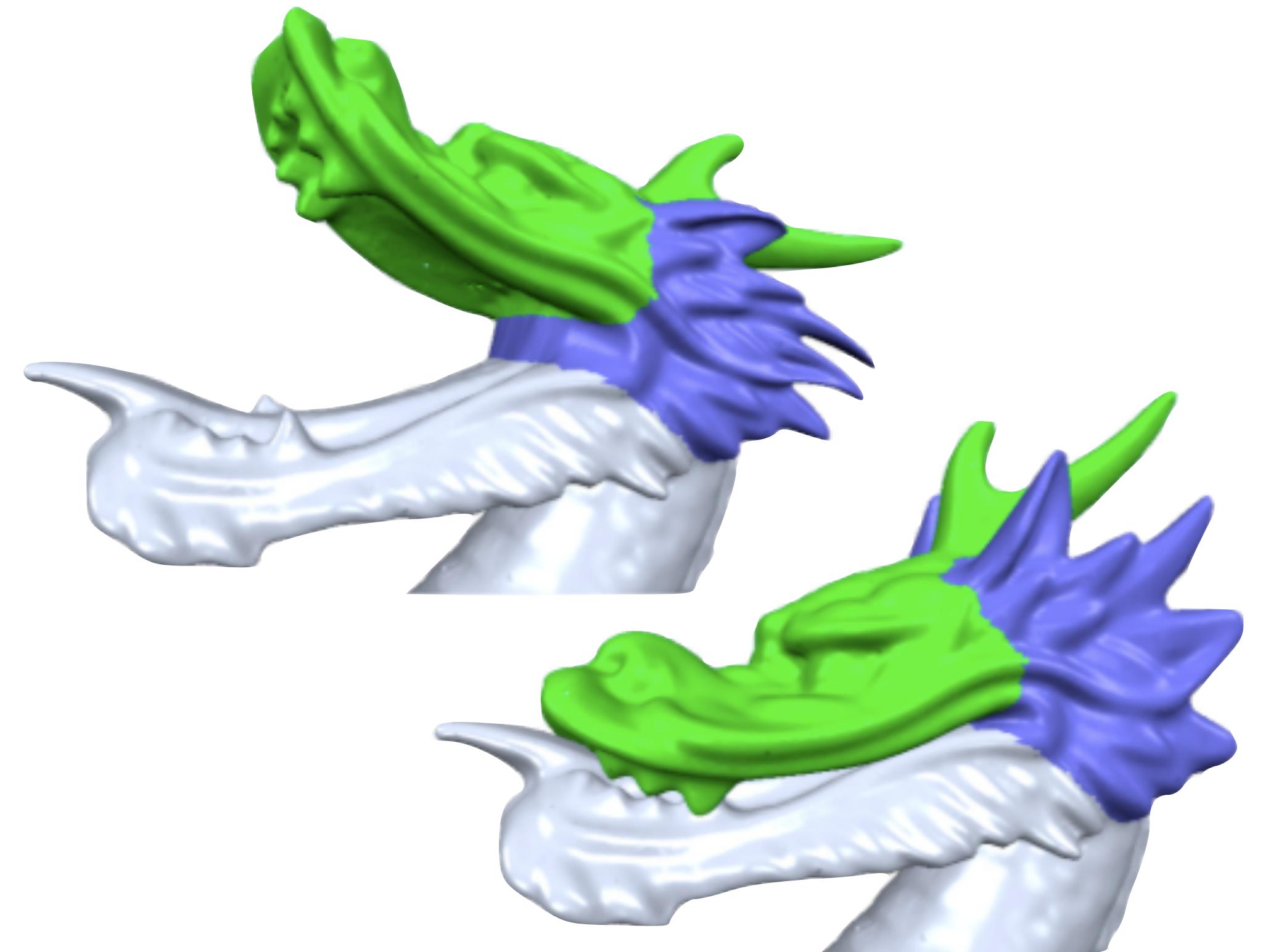
<http://dl.acm.org/citation.cfm?id=1665834>

5. Mesh Deformation

- handle-driven mesh deformation



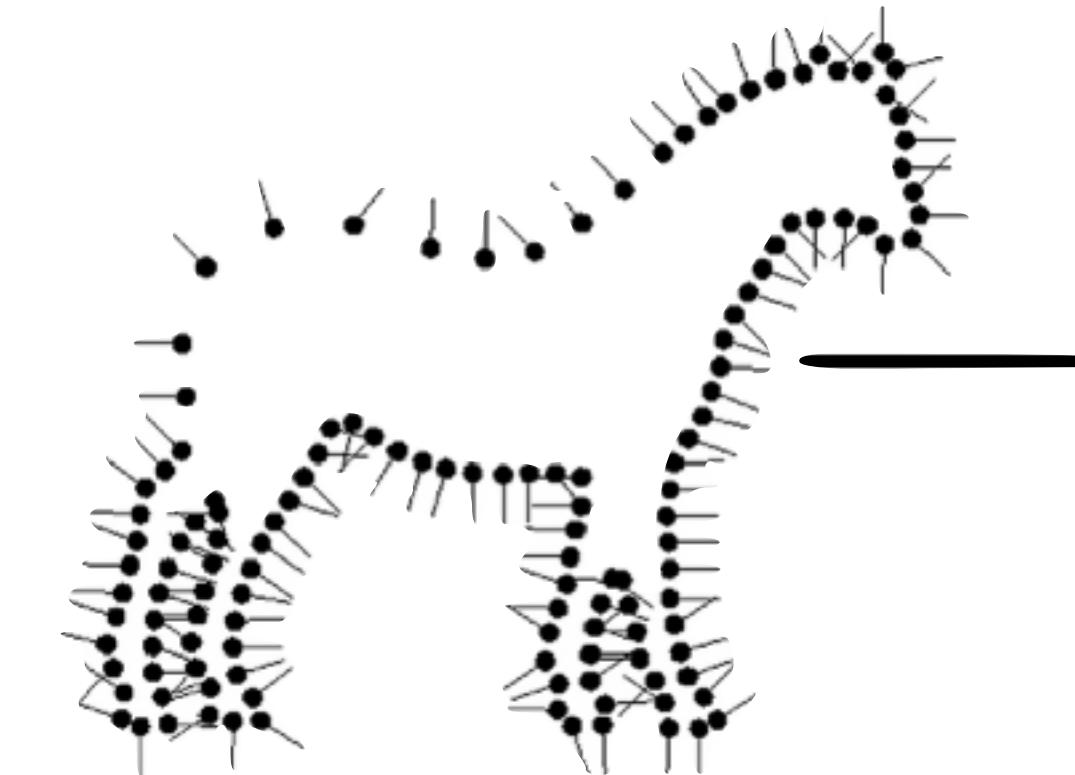
- skill set:
 - simple UI
 - more operations with mesh Laplacian



[paper](#): see class notes

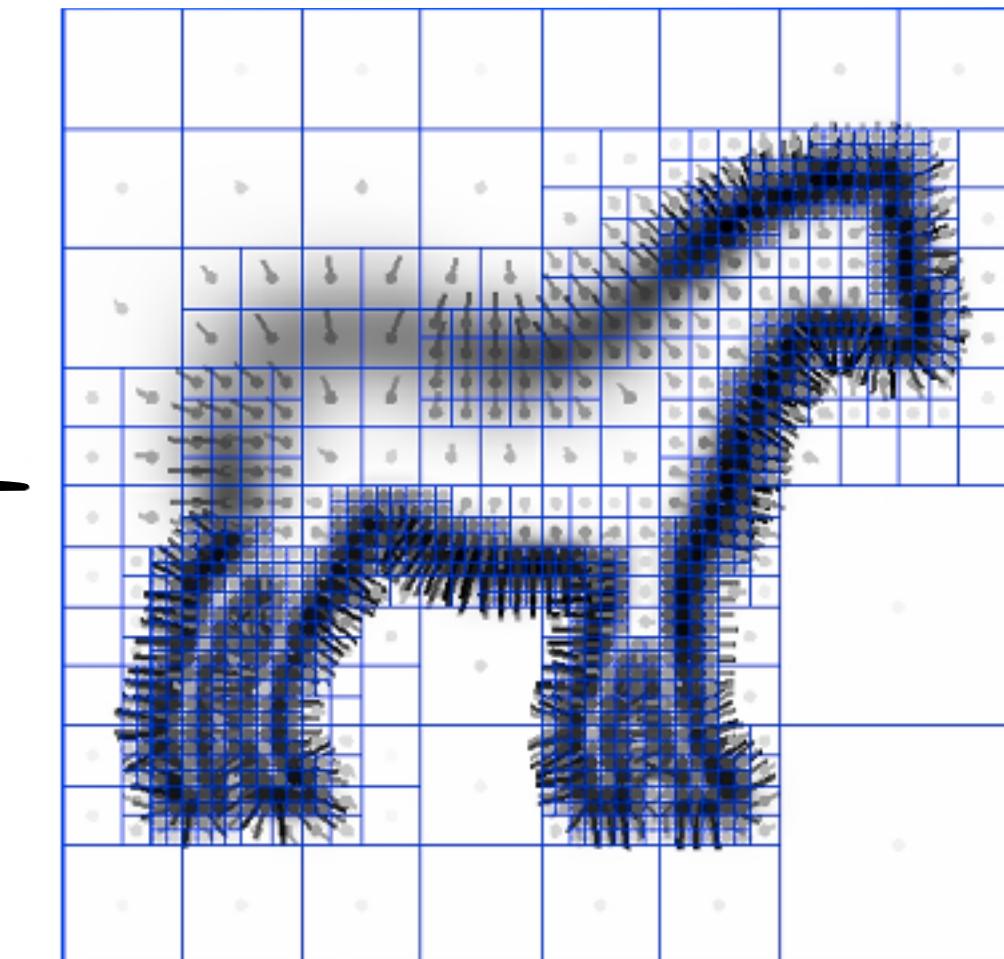
6. Surface Reconstruction

- Implement Marching Cubes (OR) Poisson Reconstruction



- skill set:

- simple, but have to work with low level data operations



paper: <http://hhoppe.com/poissonrecon.pdf>

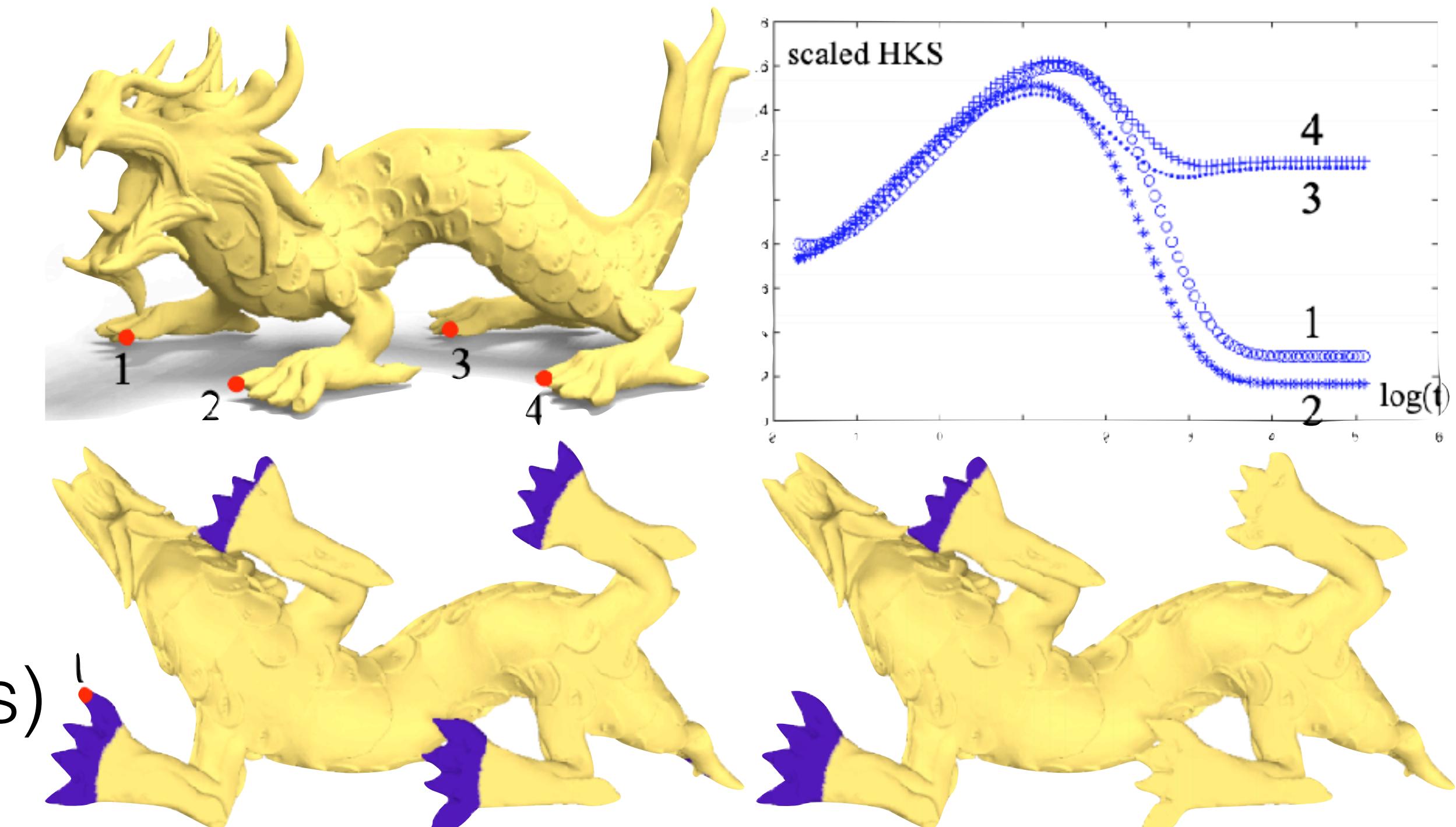
7. Shape Signatures and Retrieval

- Use LB operator and its eigen vectors

2, 3

- skill set:

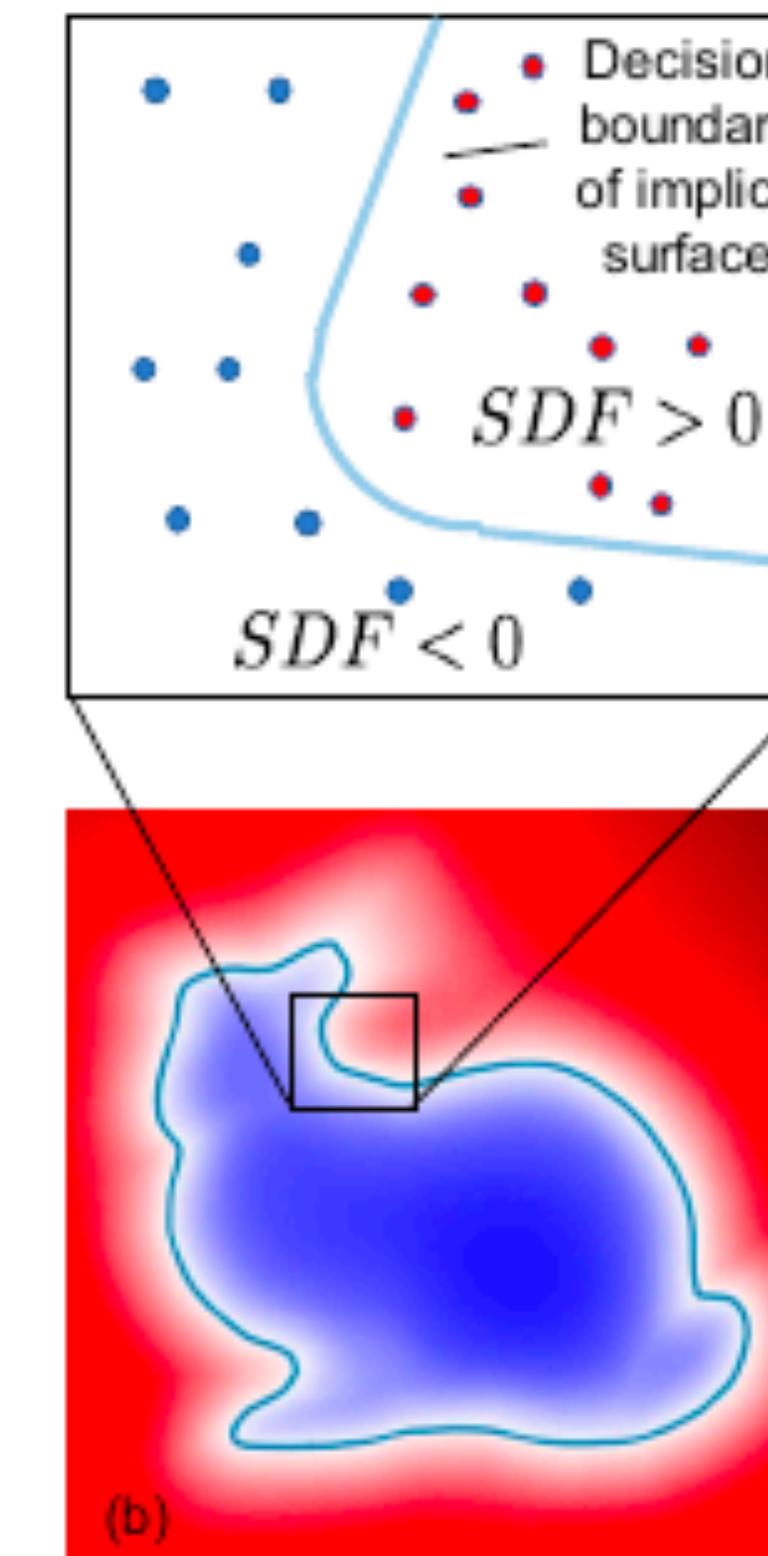
- compute LB operator (CW2)
- design suitable evaluation (PR curves)



paper: <http://www.lix.polytechnique.fr/~maks/papers/hks.pdf>

8. Neural Representations

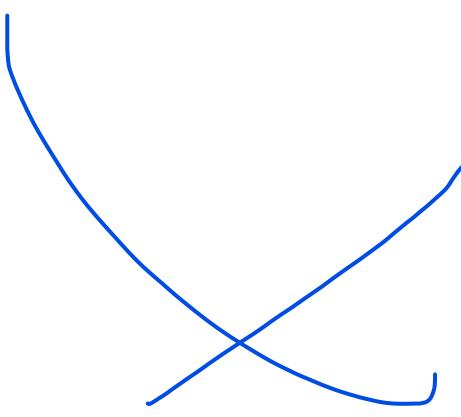
- MLP to represent Implicit Functions
- $f_{\theta}(\mathbf{z}, \mathbf{p})$
- skill set:
 - Basics in ML
 - Marching cubes
 - Denoise using this representation?



paper: <https://arxiv.org/abs/1901.05103> +

<http://geometry.cs.ucl.ac.uk/projects/2019/pointcleannet/>

9. Neural ICP

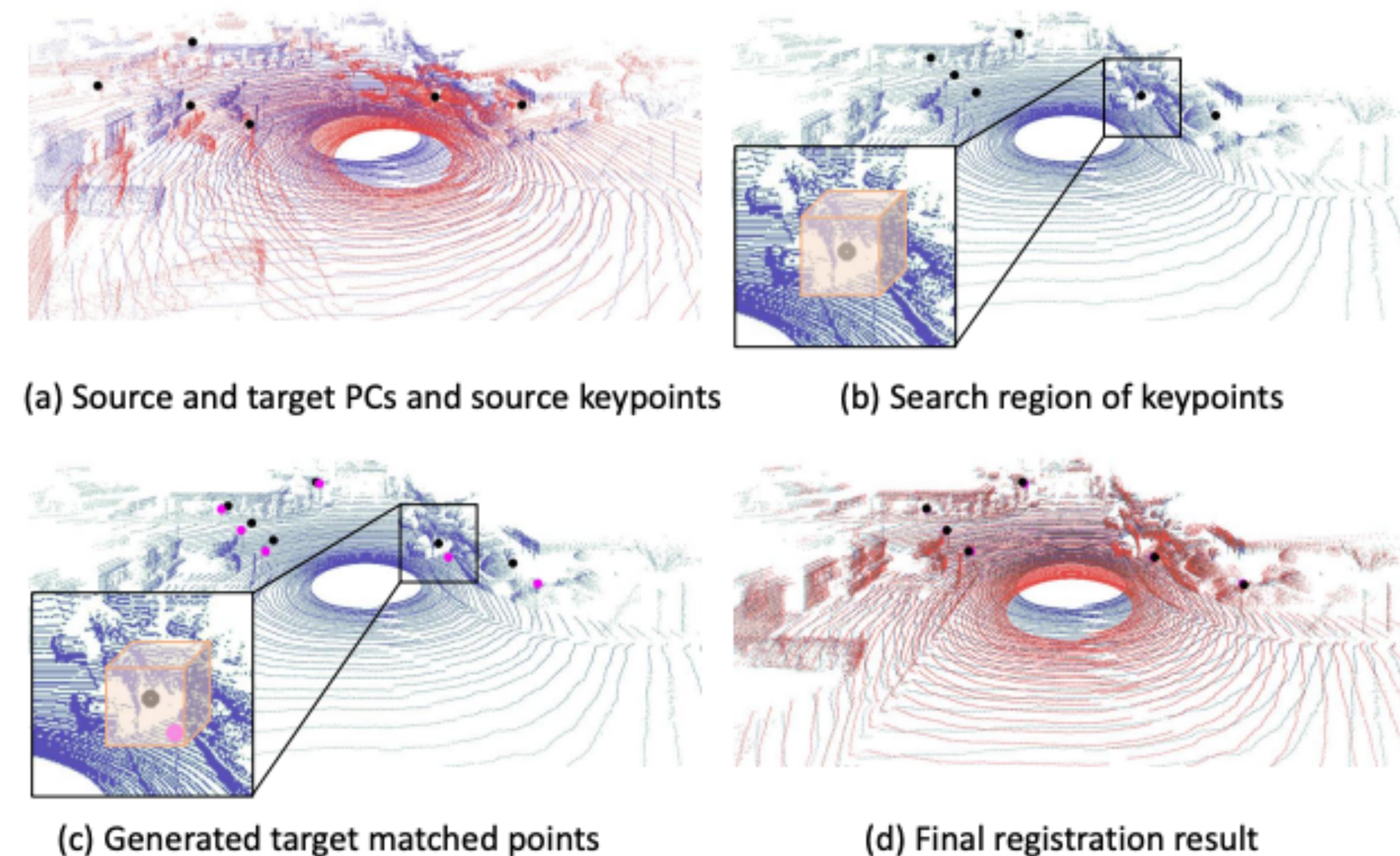


- Register scan and update SDF as $f_\phi(\mathbf{p})$

- skill set:

- Basics in ML

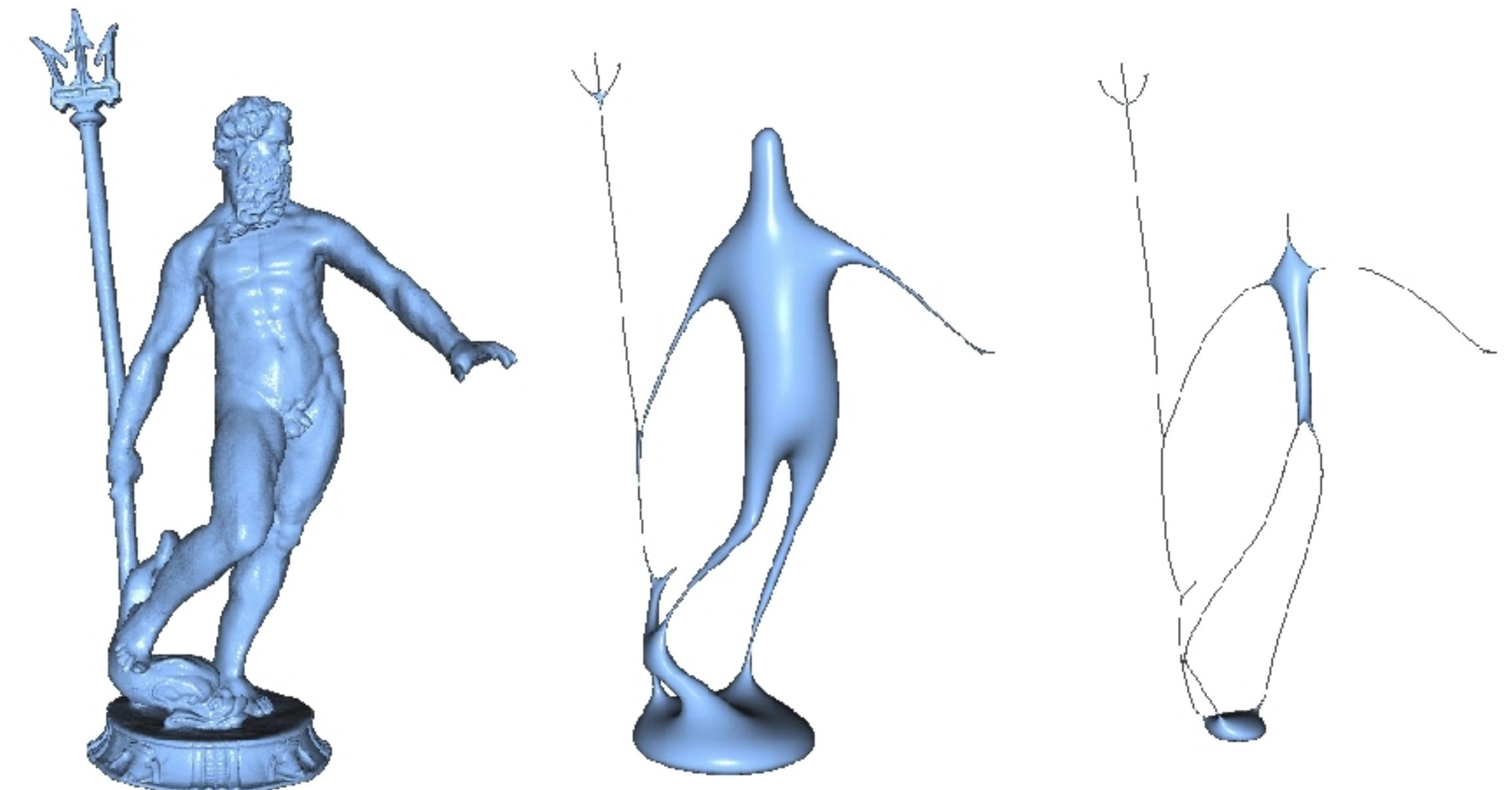
- Rethink the formulation or implement the paper



paper: <https://arxiv.org/pdf/1905.04153.pdf>

10. Mean Curvature Flow

- compute Mean Curvature Flow
- generate gallery of minimal surfaces
- skill set:
 - basic understanding of differential geometry
(CW #2)

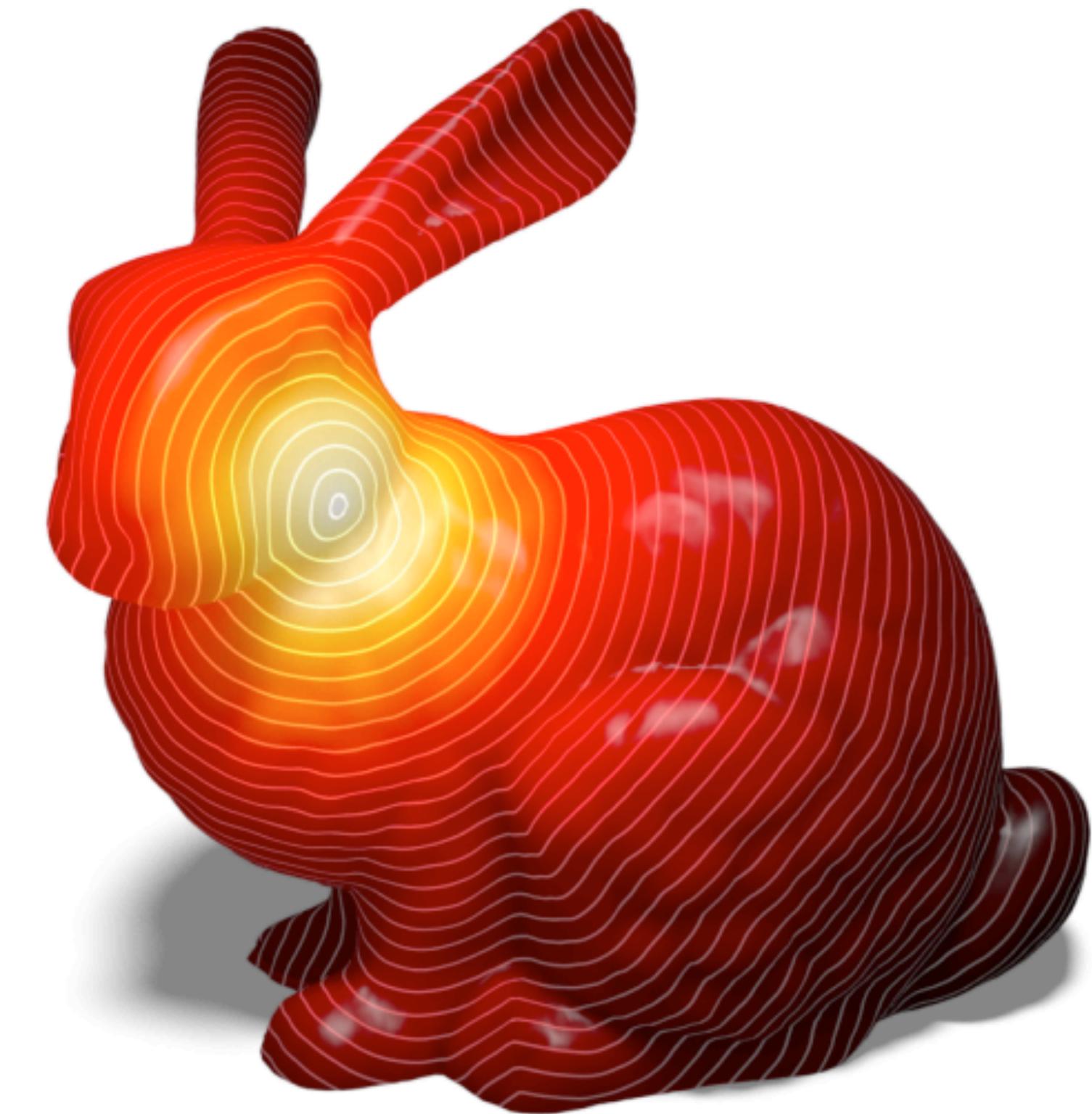


paper: https://www.cs.sfu.ca/~haoz/pubs/tag_sgp12.pdf

11. Geodesic Distance

Algorithm 1 The Heat Method

- I. Integrate the heat flow $\dot{u} = \Delta u$ for some fixed time t .
 - II. Evaluate the vector field $X = -\nabla u / |\nabla u|$.
 - III. Solve the Poisson equation $\Delta \phi = \nabla \cdot X$.
-



pdf: <http://ddg.math.uni-goettingen.de/pub/GeodesicsInHeat.pdf>

12. Learning to Estimate Normals

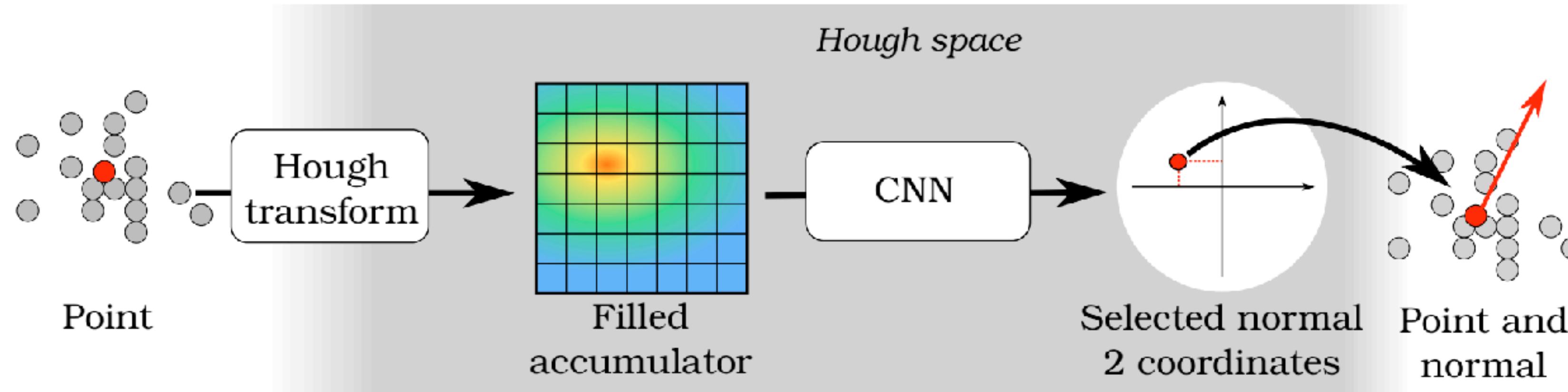


Figure 1: Our CNN-based normal estimation framework.

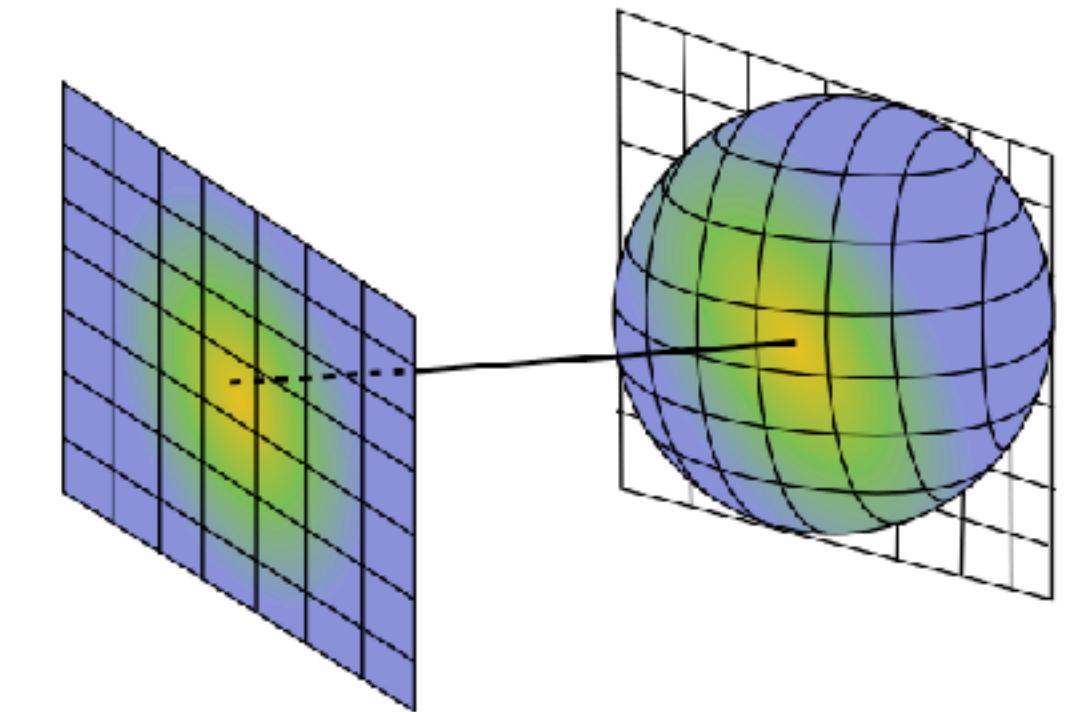
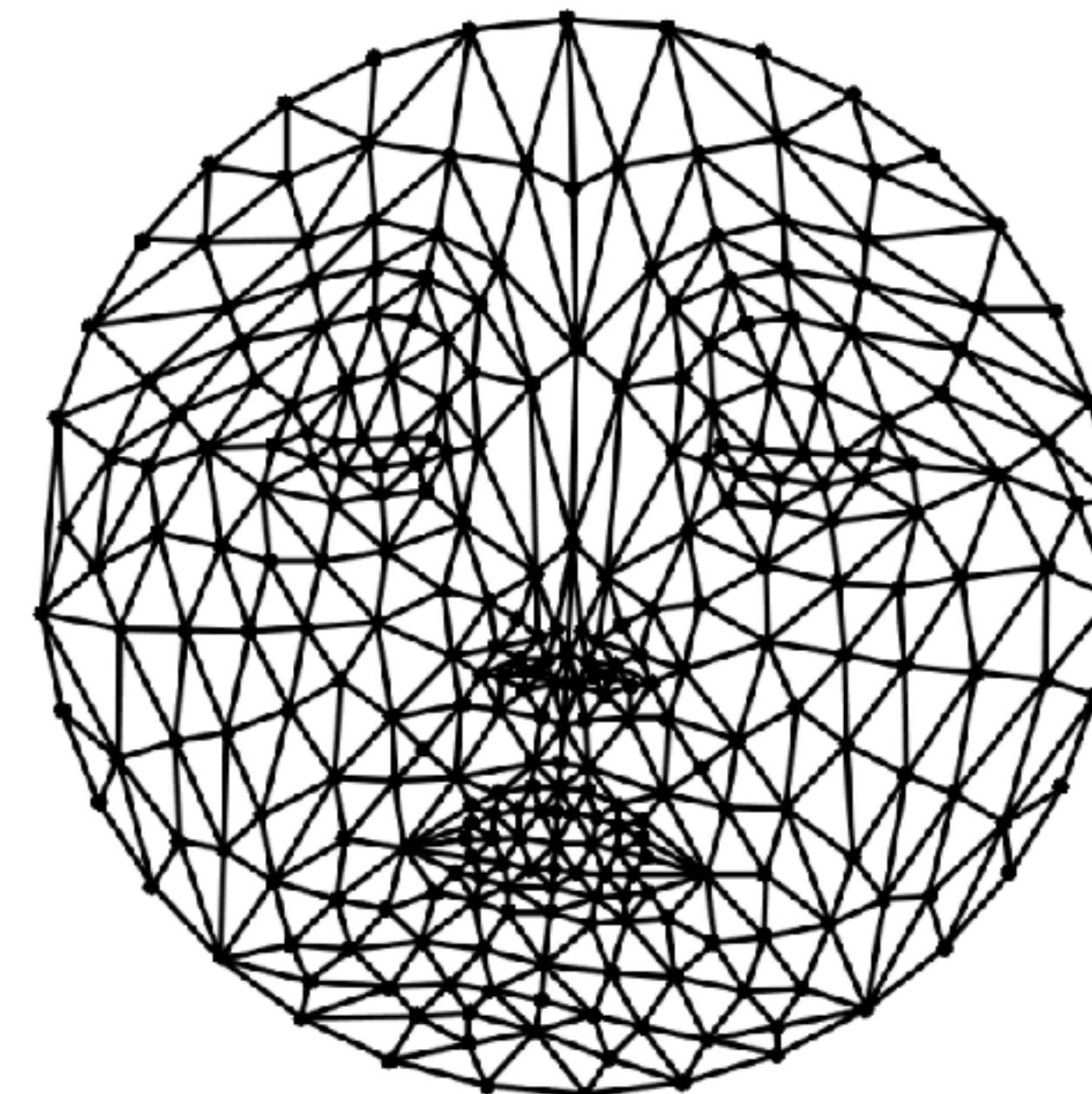


Figure 2: Distortion of bins when projected on the sphere.

13. Spectral Mesh Flattening

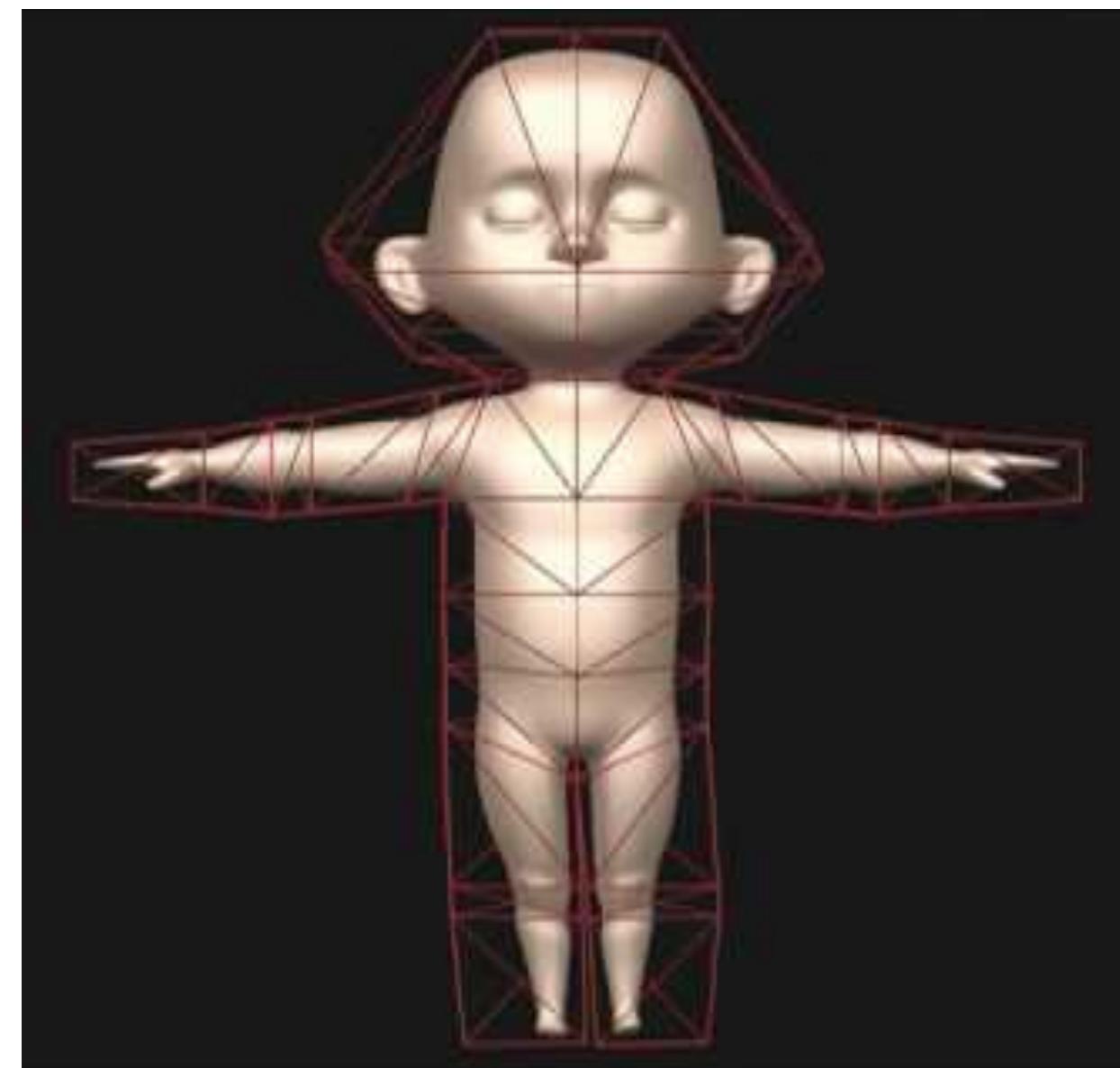
- Map mesh boundary to convex polygon
- Solve Tutte's embedding method
 - Circle
 - Square



14. Harmonic Coordinates

- Implement/test in 2D

P. Joshi, M. Meyer, T. DeRose, B. Green and T. Sanocki *Harmonic coordinates for character articulation* ACM Trans. Graph, 3(26), p.71, 2007



15. Differential Geometry on Implicit Surfaces

- Assume access to an implicit surface

https://dsilvavinicio.github.io/differential_geometry_in_neural_implicit/assets/novello2022exploring.pdf

