Sphere-based Cut Construction for Planar Parameterizations

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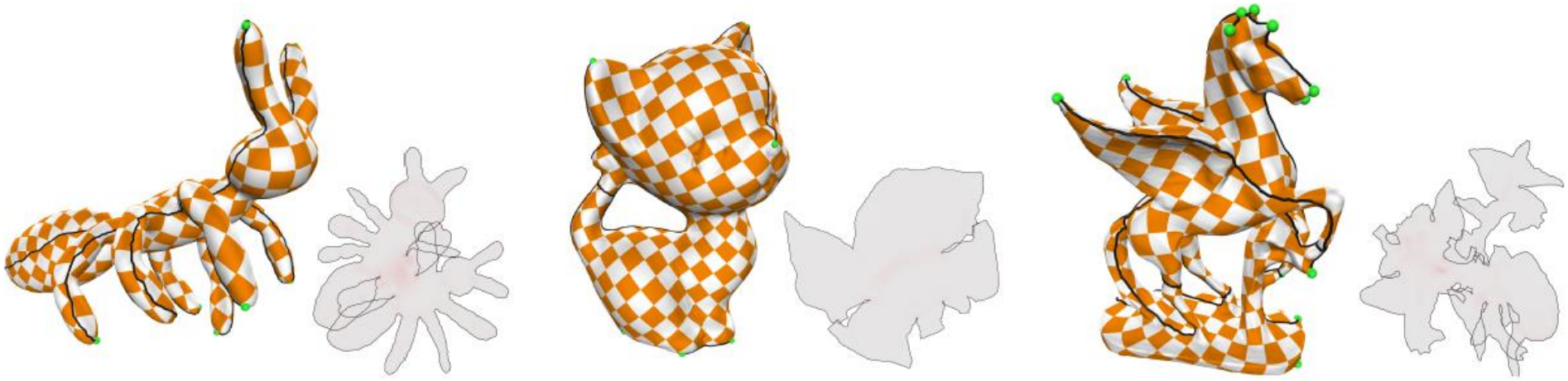
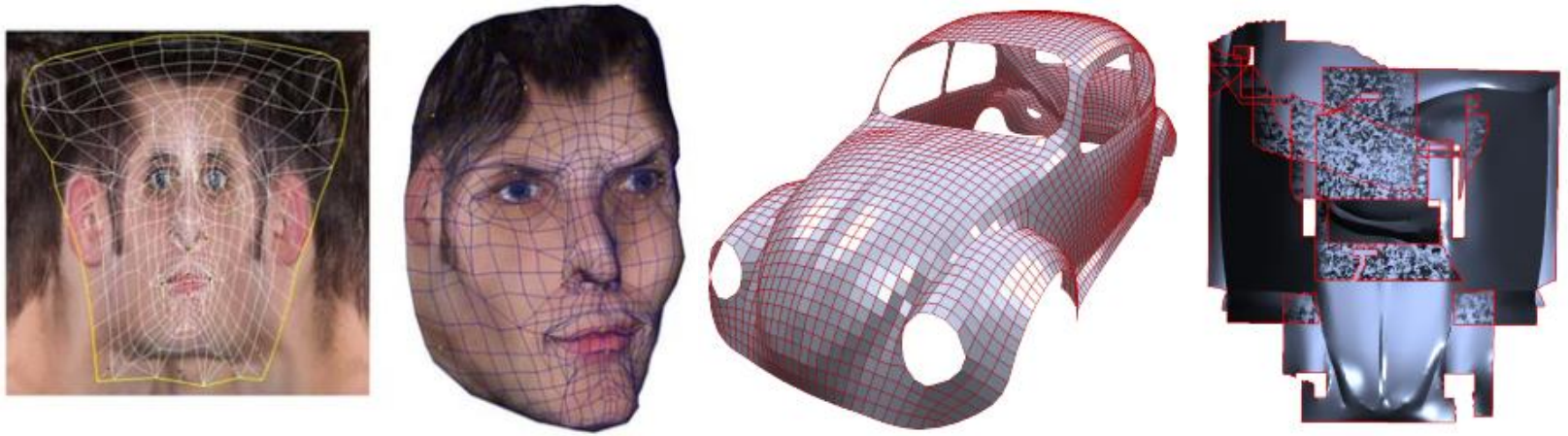
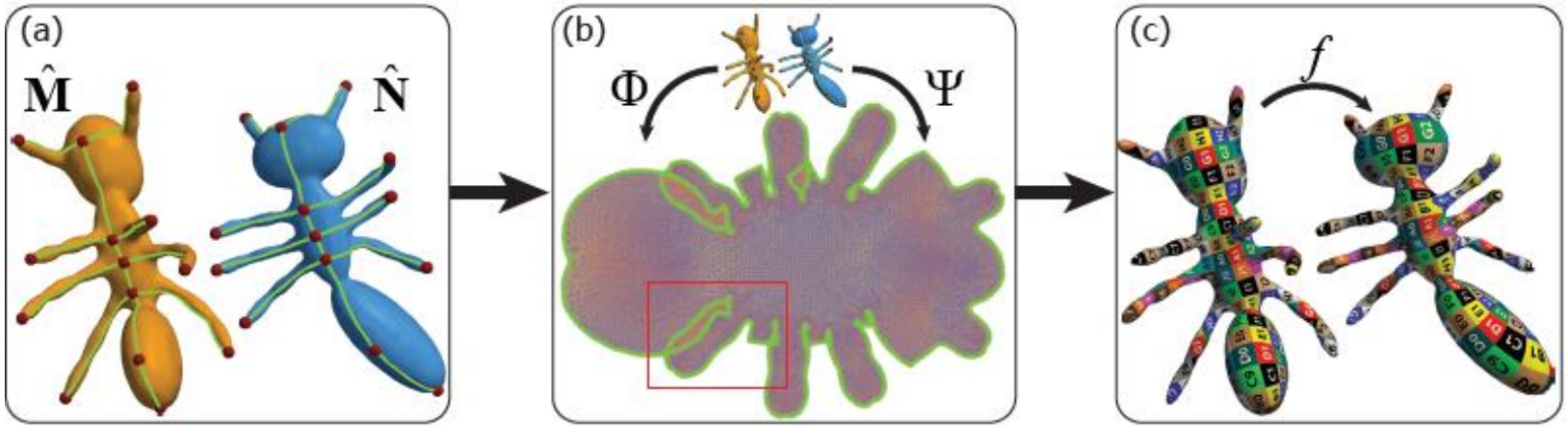


SMI 2018 @ Lisbon, Portugal

Applications of Parameterization

- Texture mapping
  (many papers)
- Remeshing
  [Bommes et al., 2009]
- Inter-surface mapping
  [Aigerman et al., 2014]
- …



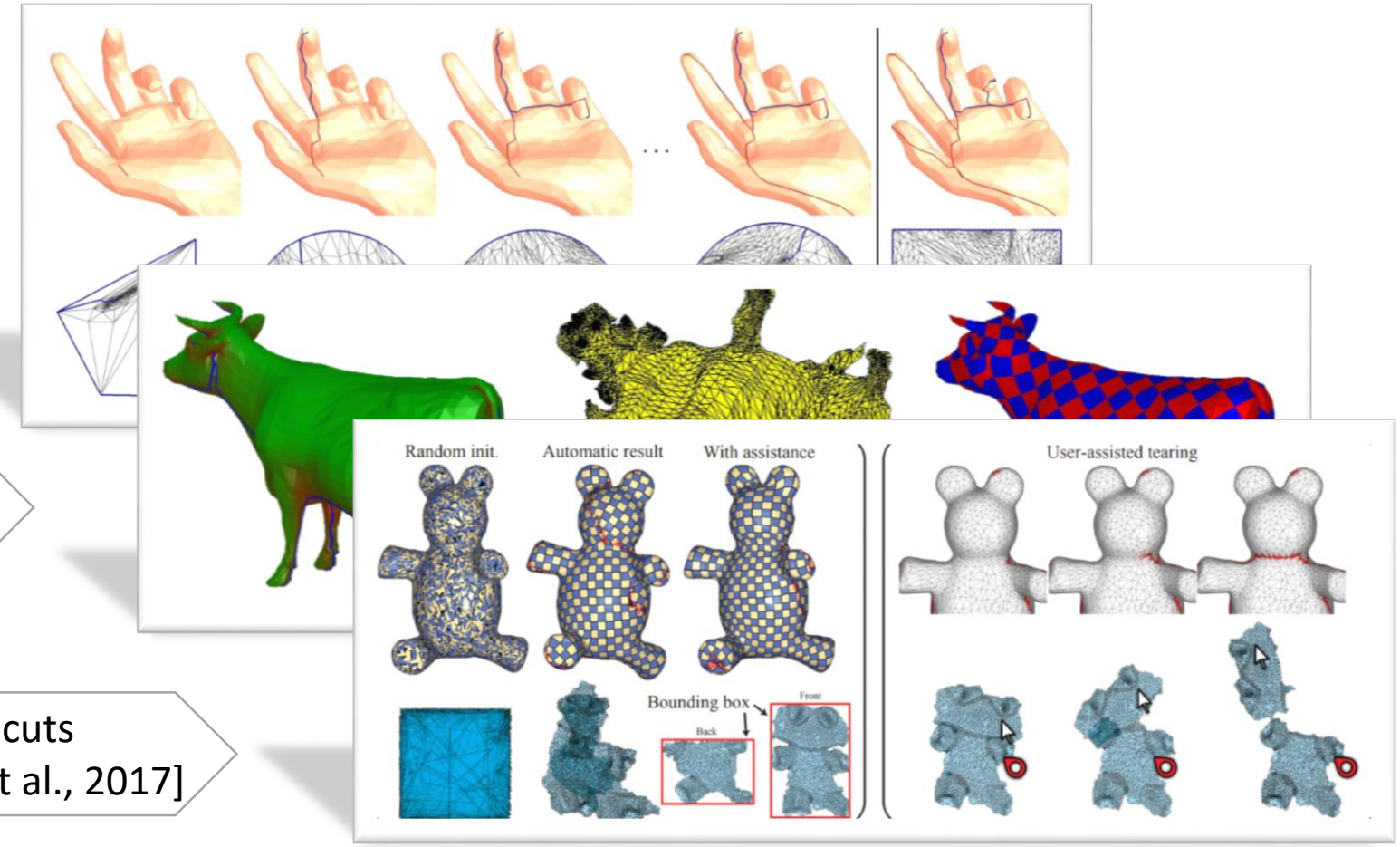


Previous Work

Geometry Images
[Gu et al., 2002]

Seamster
[Sheffer and Hart, 2002]

Autocuts
[Poranne et al., 2017]



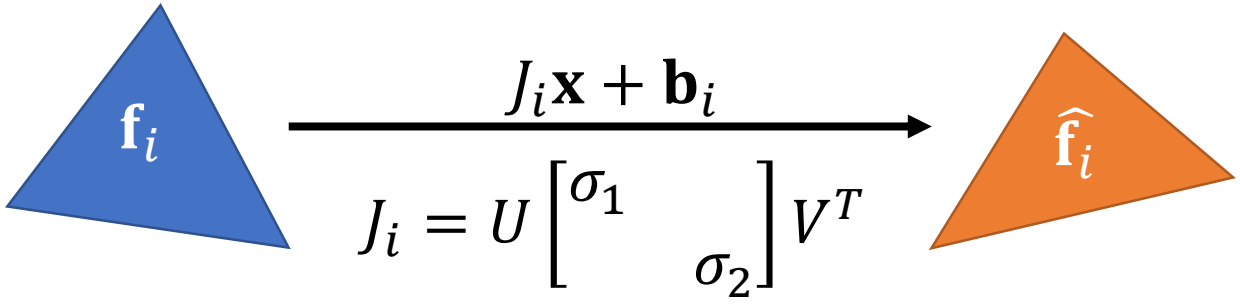
Goal

- A cut construction method that satisfies
  - The distortion of a subsequent planar parameterization is low.
  - The cuts are feature-aligned, resulting in visual beauty.
  - The cuts are short.

- It is challenging to satisfy all the above requirements.

Method

Mapping, Parameterization & Distortion



- Distortion metrics
  - Conformal distortion (angle preserving) [Hormann et al., 2000]

$$d_i^{\text{conf}} = \frac{1}{2}\left(\frac{\sigma_1}{\sigma_2} + \frac{\sigma_2}{\sigma_1}\right) = \frac{1}{2}\frac{\|J_i\|^2}{\det J_i}$$

  - Areal distortion (area preserving) [Fu et al., 2015]

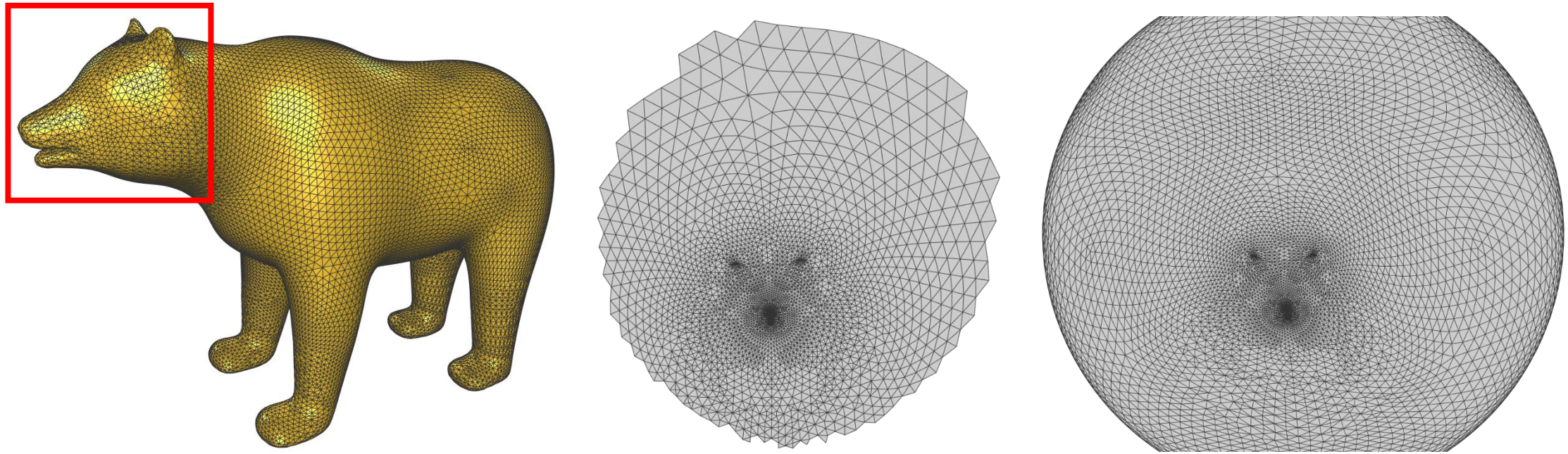
$$d_i^{\text{area}} = \frac{1}{2}(\det J_i + (\det J_i)^{-1})$$

  - Isometric distortion (isometry preserving) [Fu et al., 2015]

$$d_i^{\text{iso}} = \alpha d_i^{\text{conf}} + (1-\alpha) d_i^{\text{area}}$$

Key Observation

- The high isometric distortion mainly appears at the extrusive regions when a mesh is parameterized onto a constant curvature domain (such as a sphere or the plane) as conformal as possible.



Pipeline

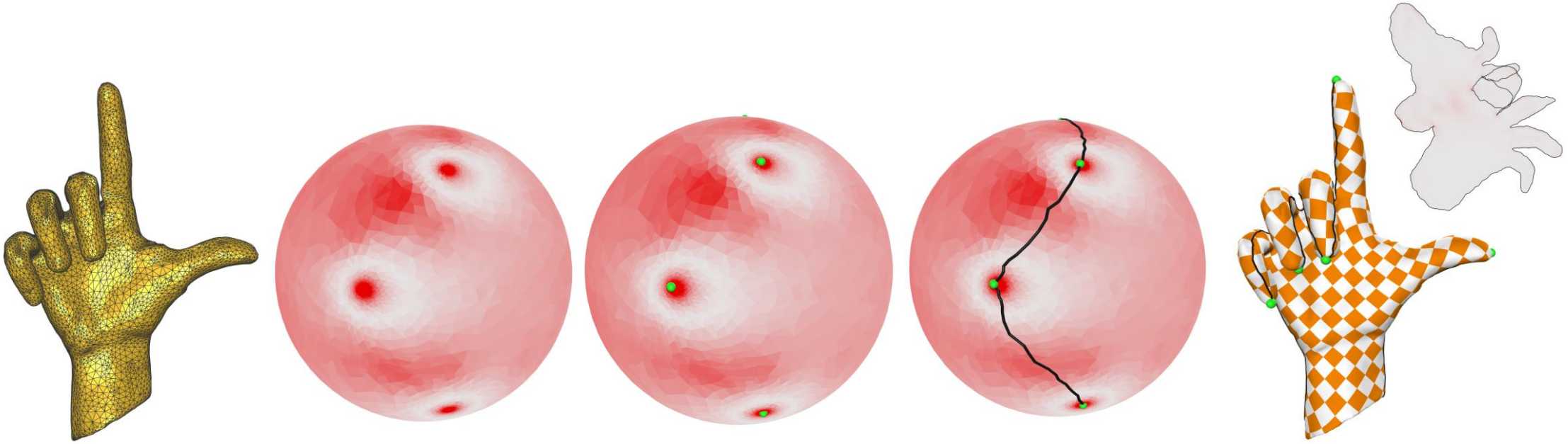
Input a closed genus-zero triangular mesh

Step 1: parameterize to a sphere ACAP

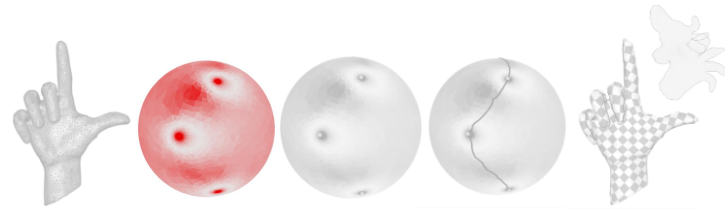
Step 2: find feature points by hierarchical clustering

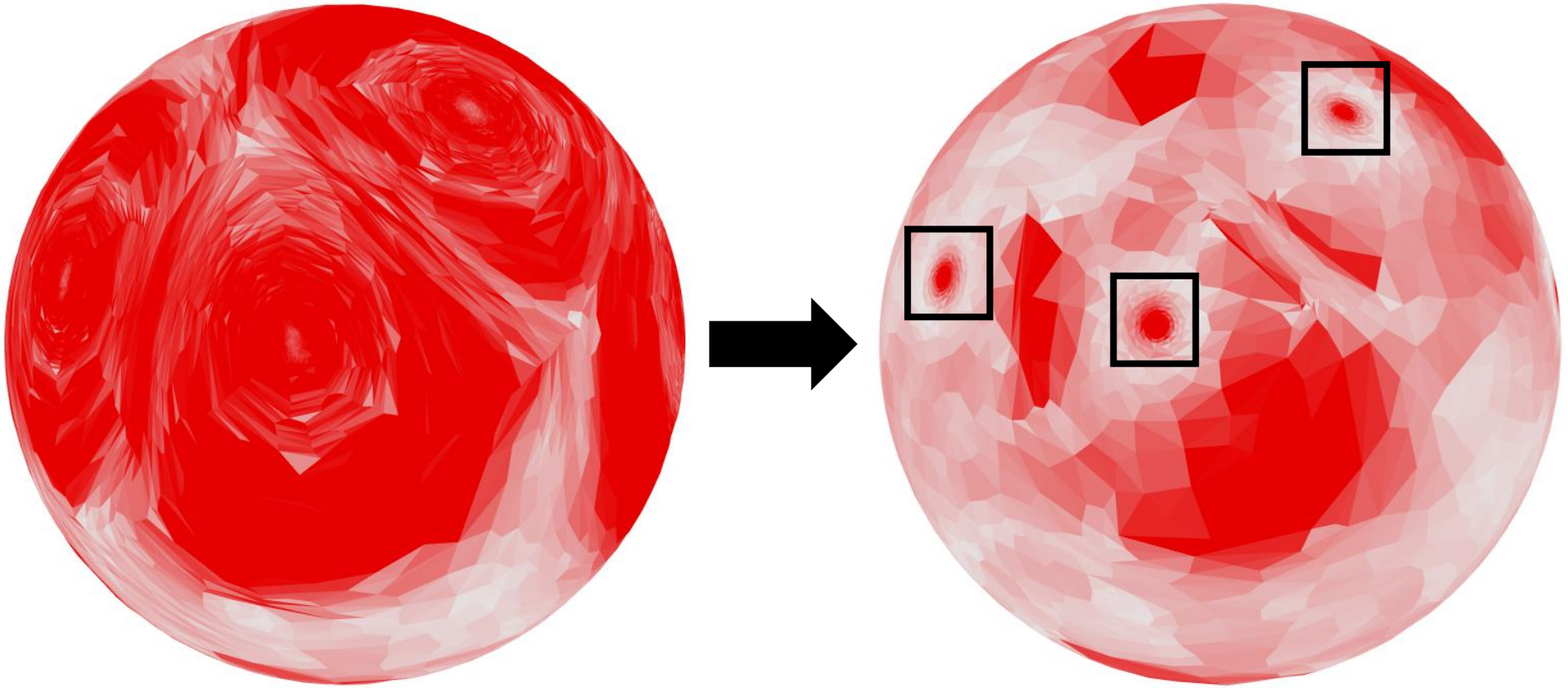
Step 3: cut by a minimal spanning tree

Output an open mesh of disk topology



ACAP Spherical Parameterization



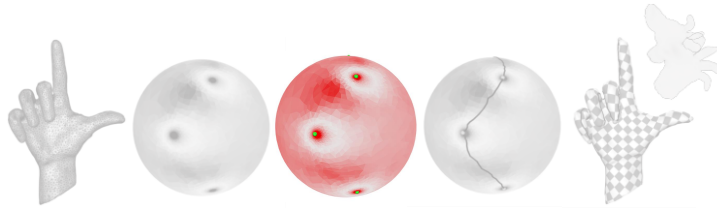


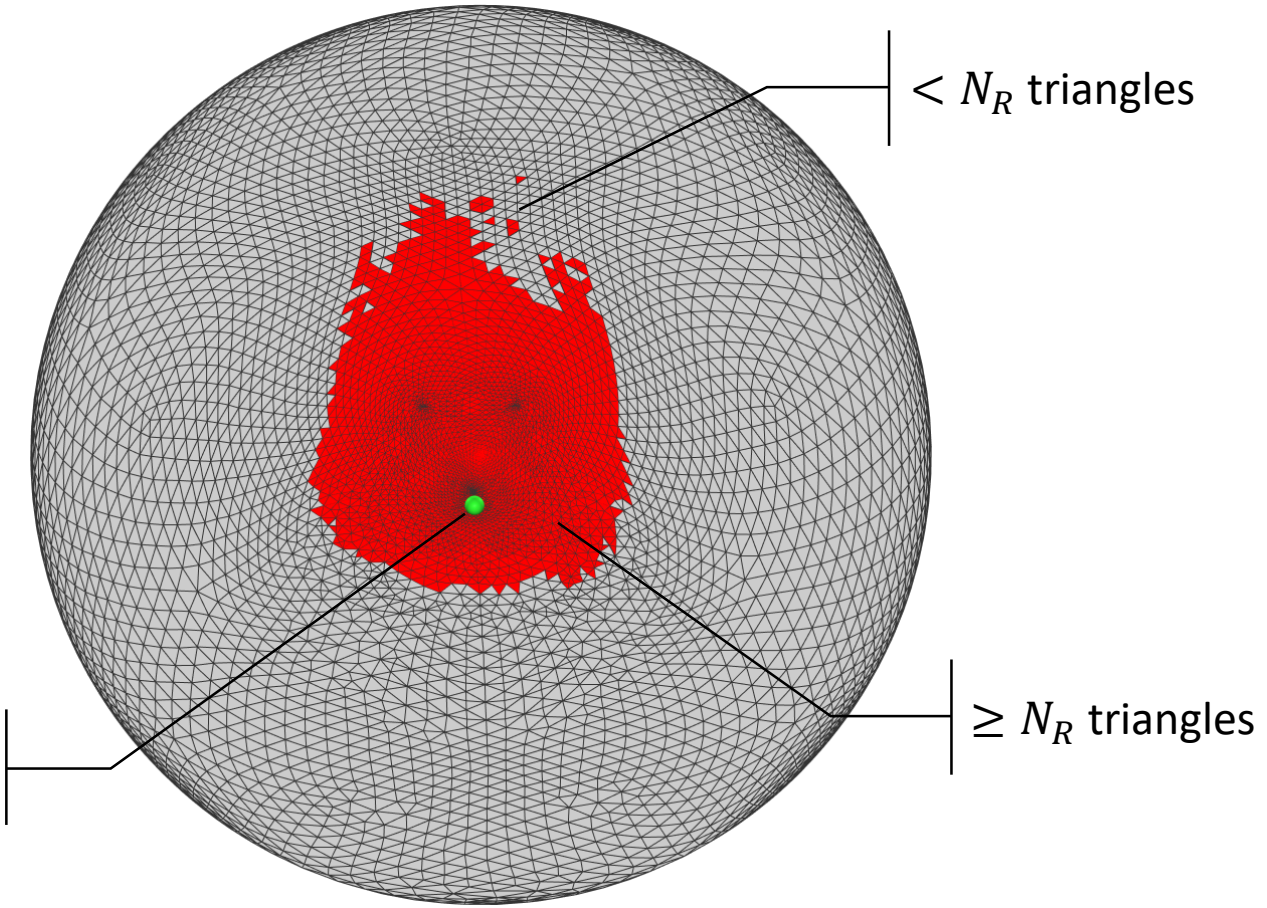
As isometric as possible (AIAP)

AHSP [Hu et al., 2018]

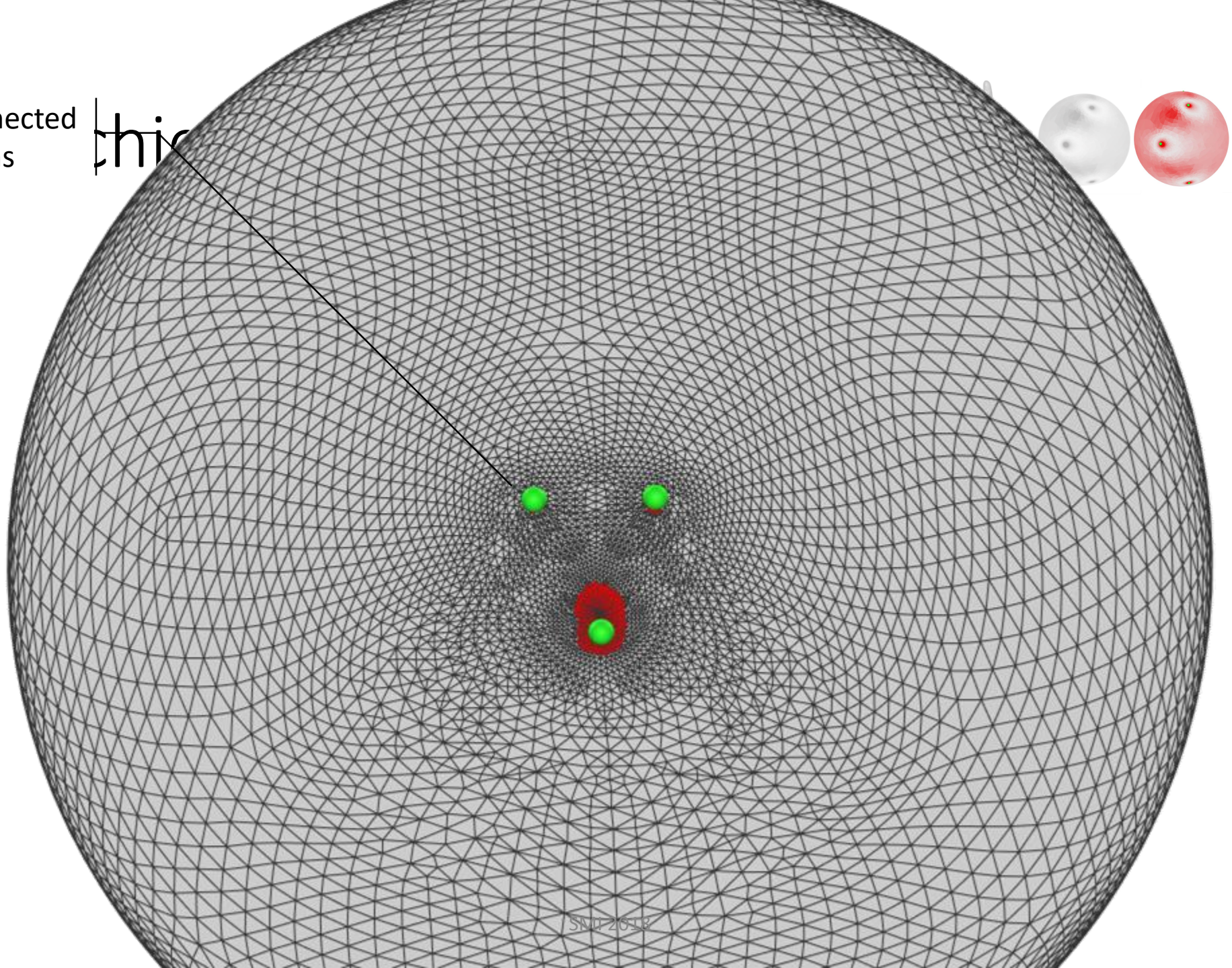
As conformal as possible (ACAP)

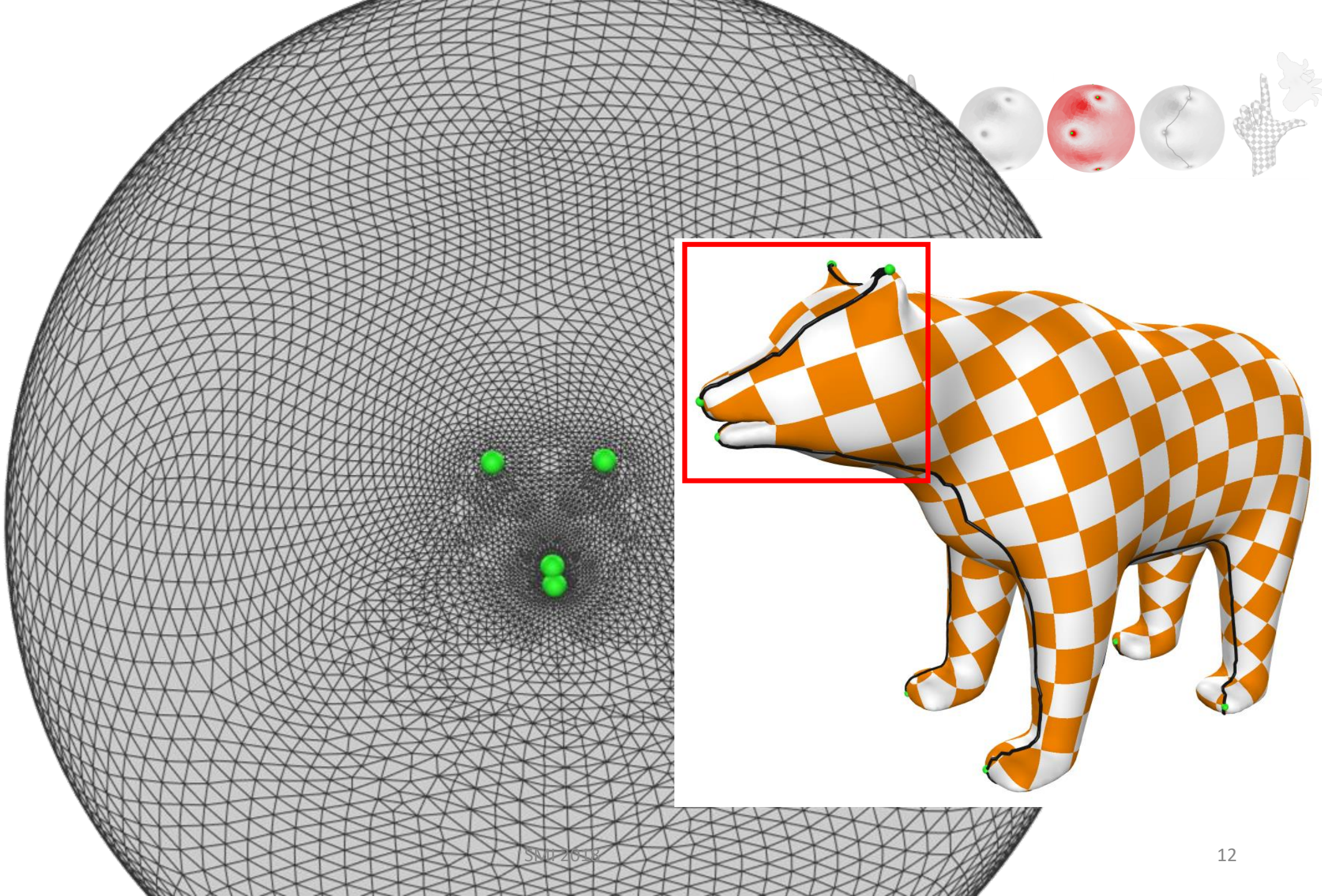
Hierarchical Clustering



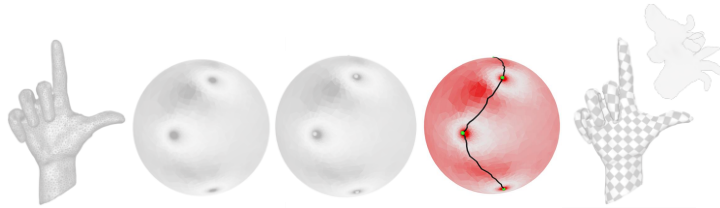


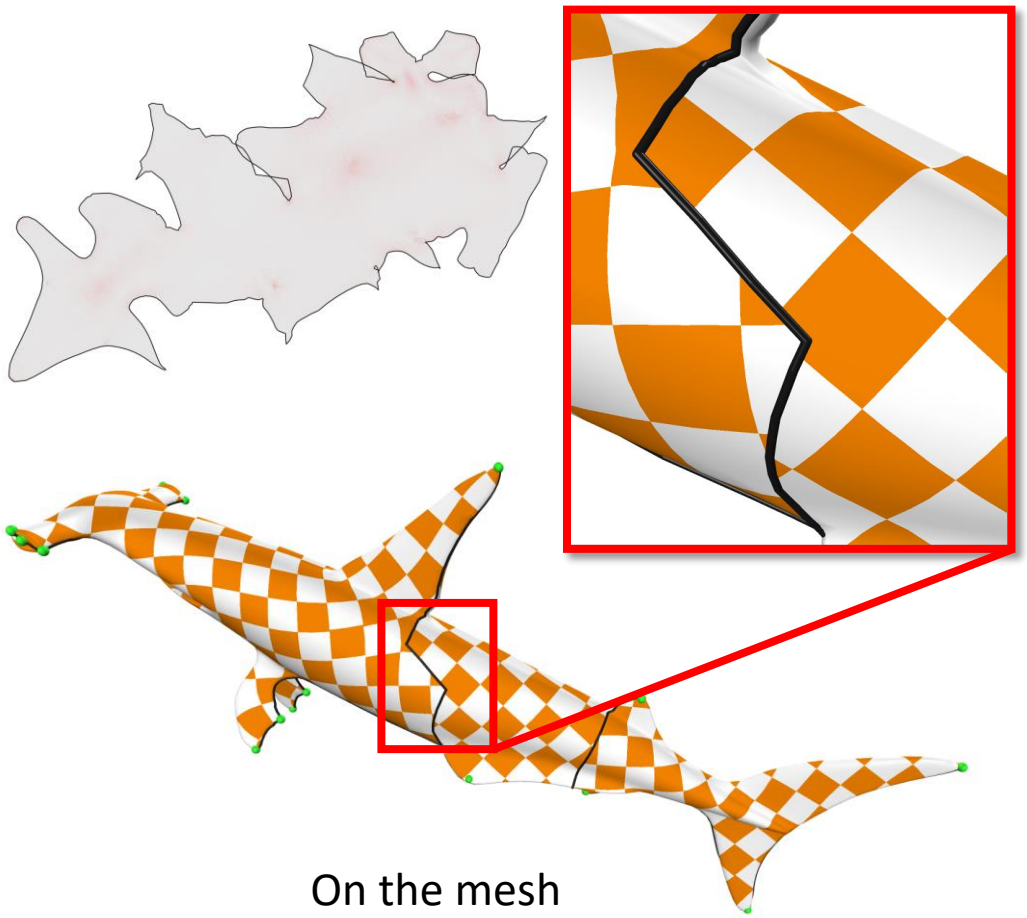
Three connected regions



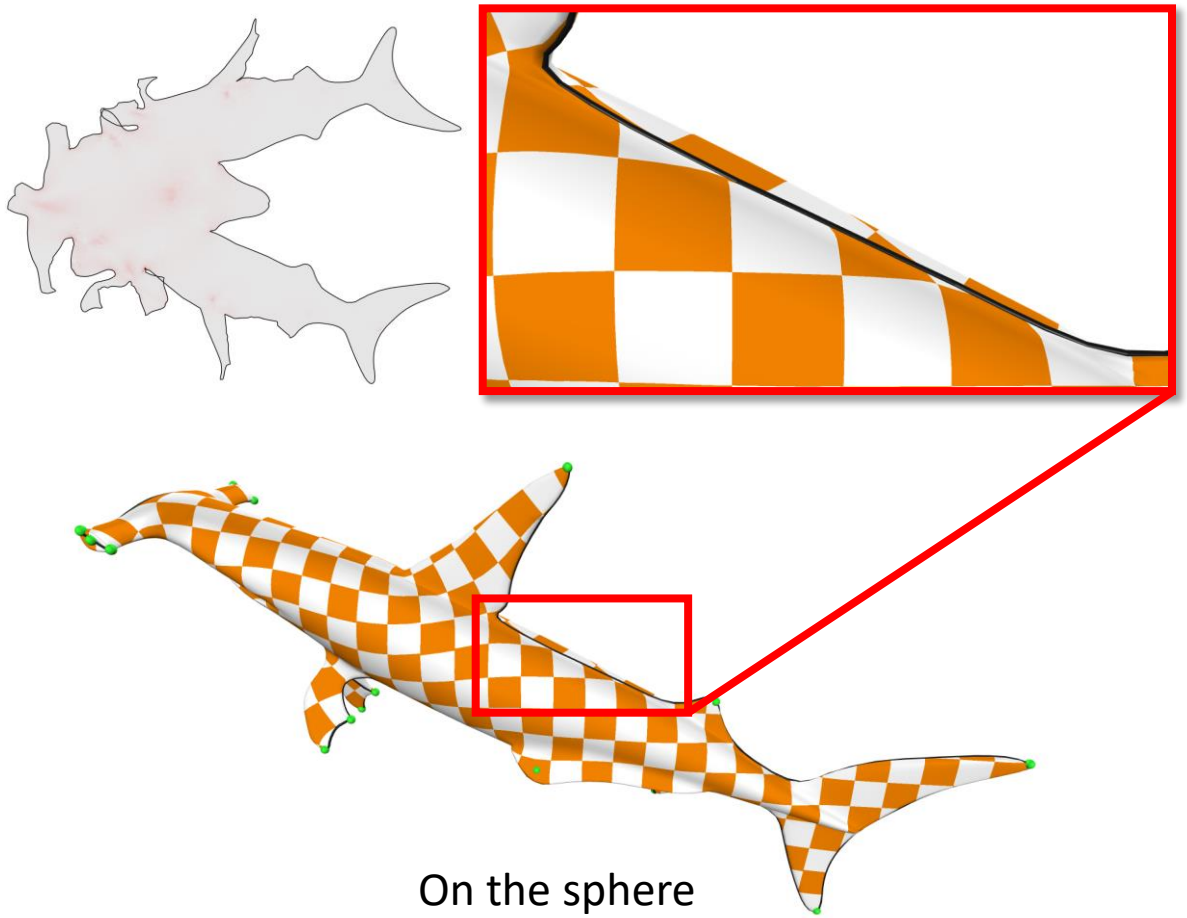


Cut Construction





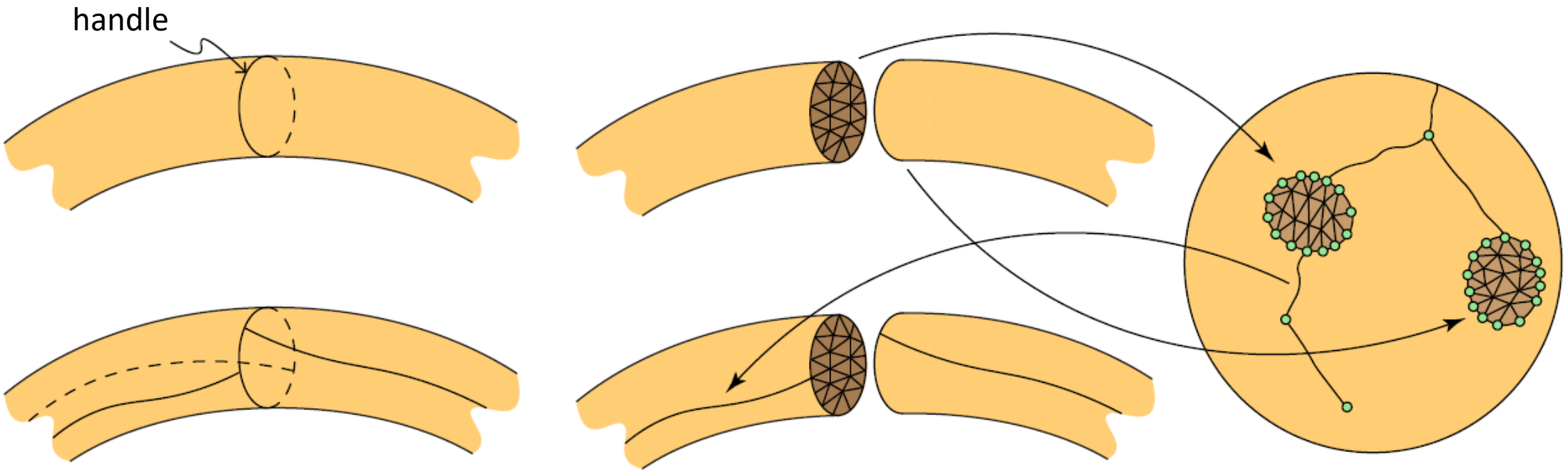
On the mesh



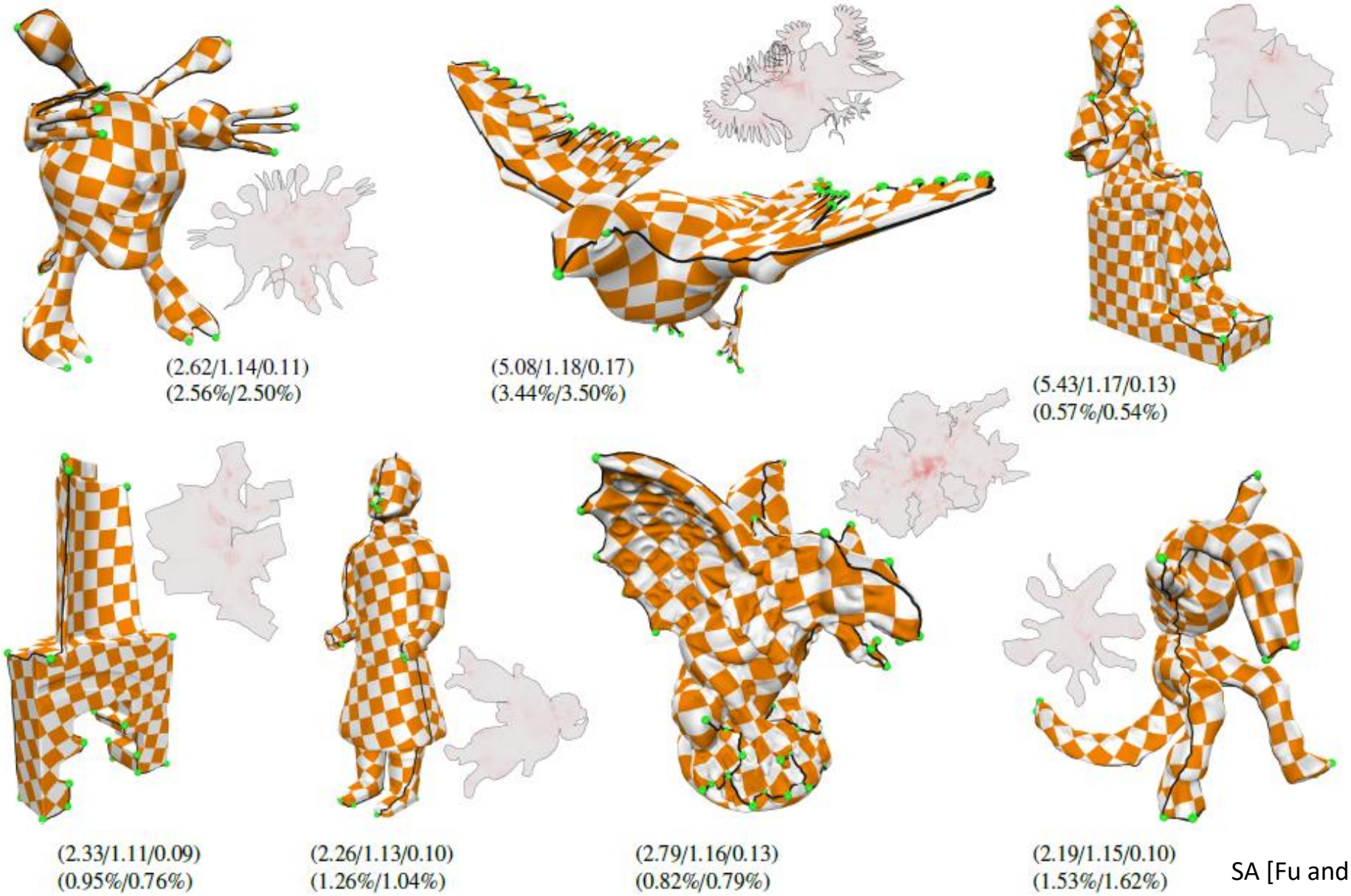
On the sphere

High-Genus Cases

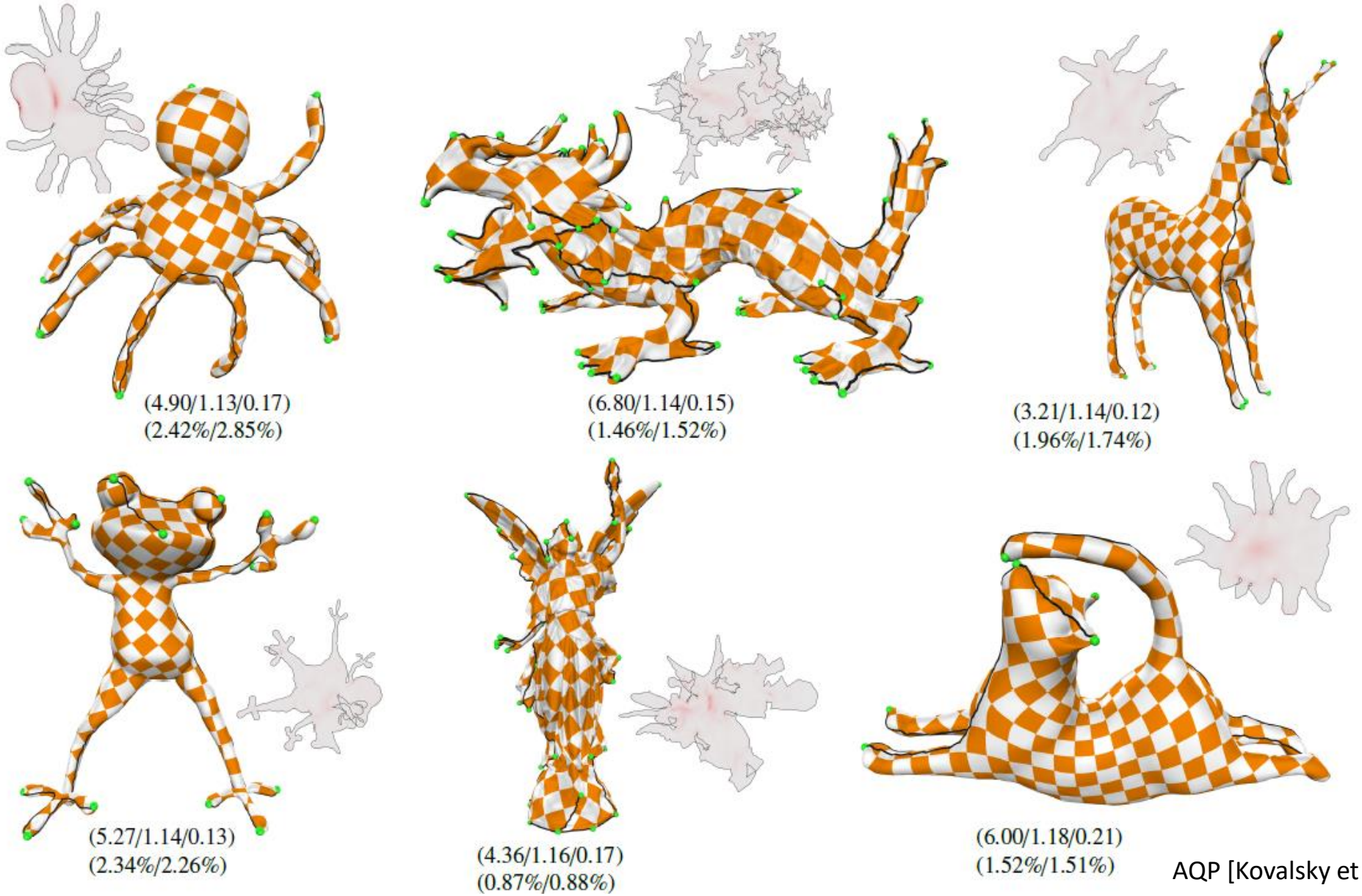
- Cut along handles [Dey et al., 2013] → Fill the holes → Apply our algorithm



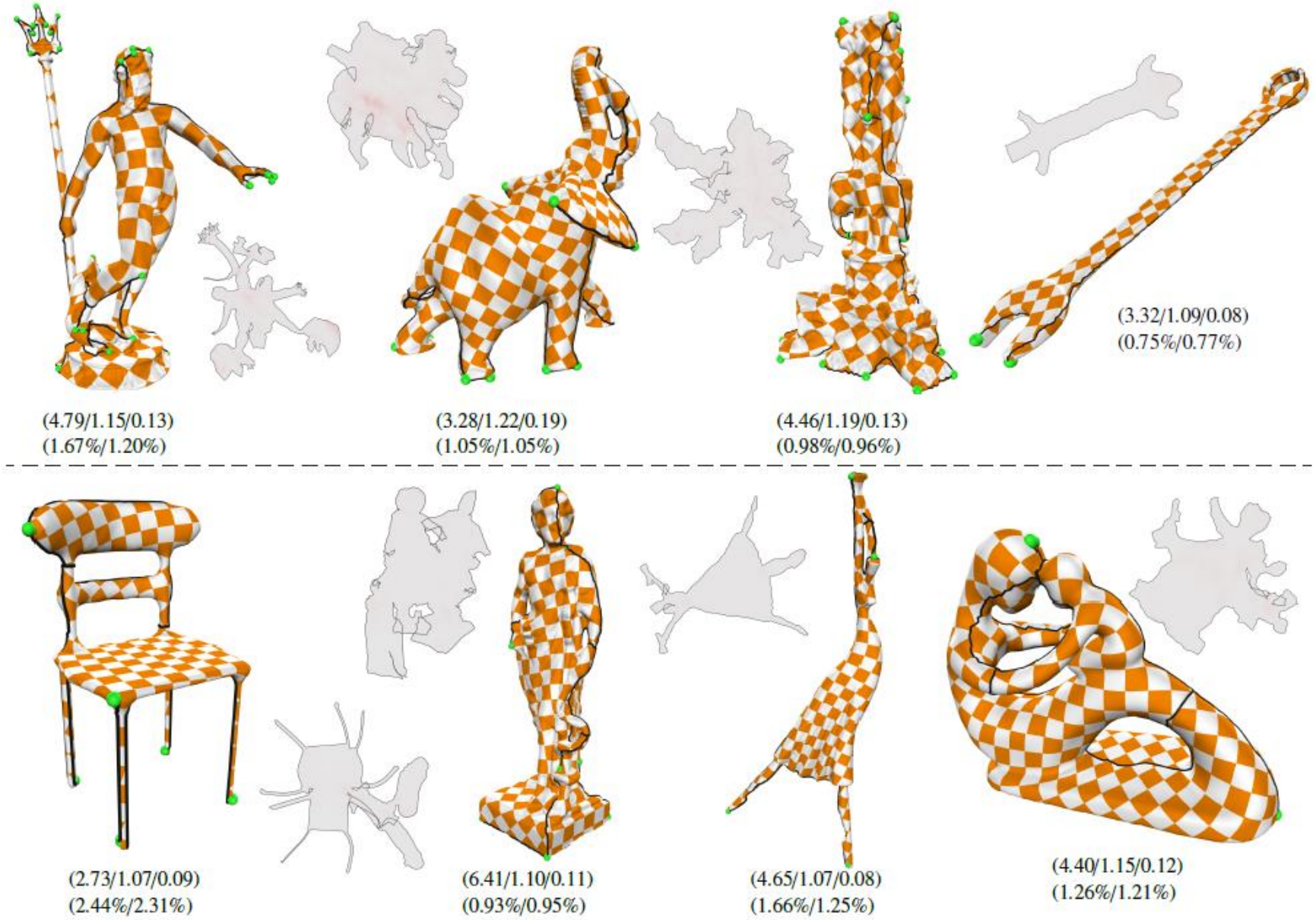
Results



SA [Fu and Liu, 2016]

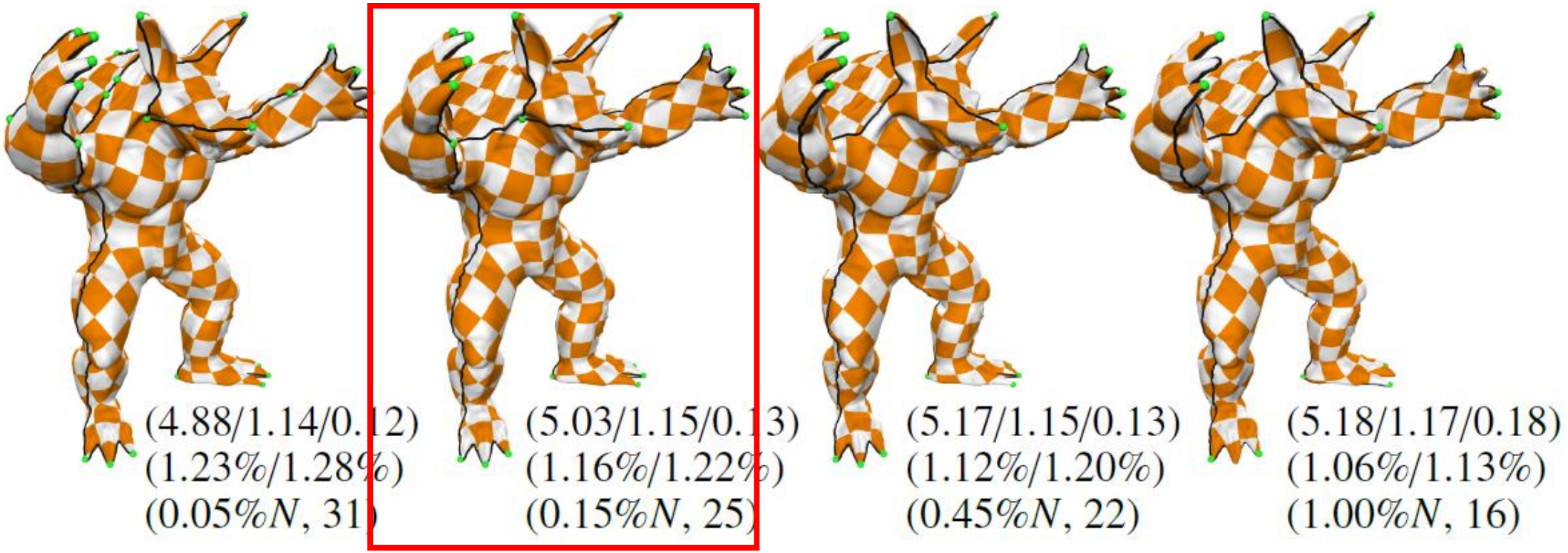


AQP [Kovalsky et al., 2016]

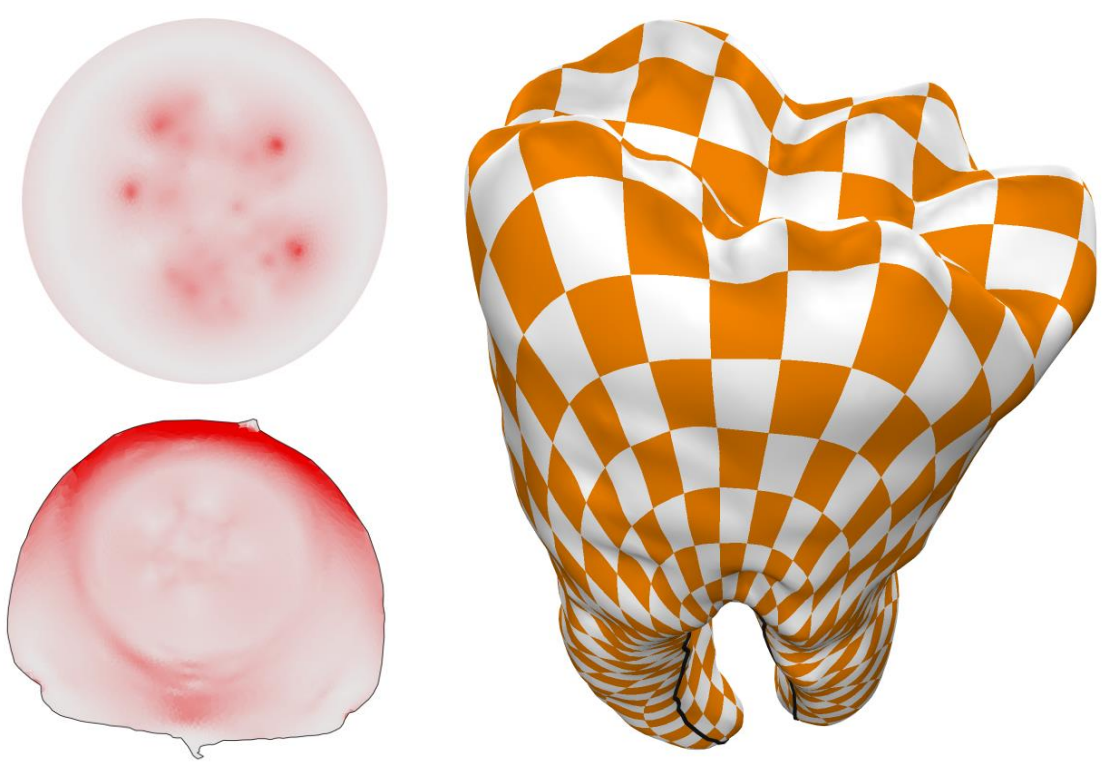

(4.79/1.15/0.13)
(1.67%/1.20%)
(3.28/1.22/0.19)
(1.05%/1.05%)
(4.46/1.19/0.13)
(0.98%/0.96%)
(3.32/1.09/0.08)
(0.75%/0.77%)
(2.73/1.07/0.09)
(2.44%/2.31%)
(6.41/1.10/0.11)
(0.93%/0.95%)
(4.65/1.07/0.08)
(1.66%/1.25%)
(4.40/1.15/0.12)
(1.26%/1.21%)

Discussions

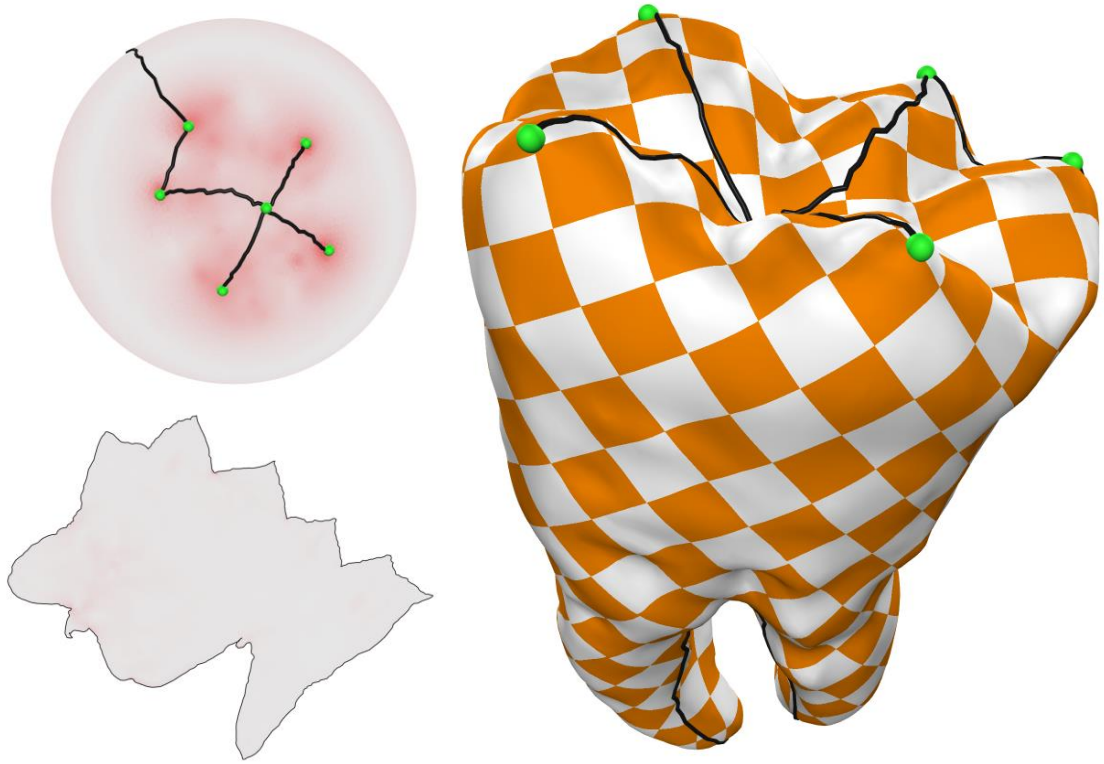
Different N_R



VS. Average Filter



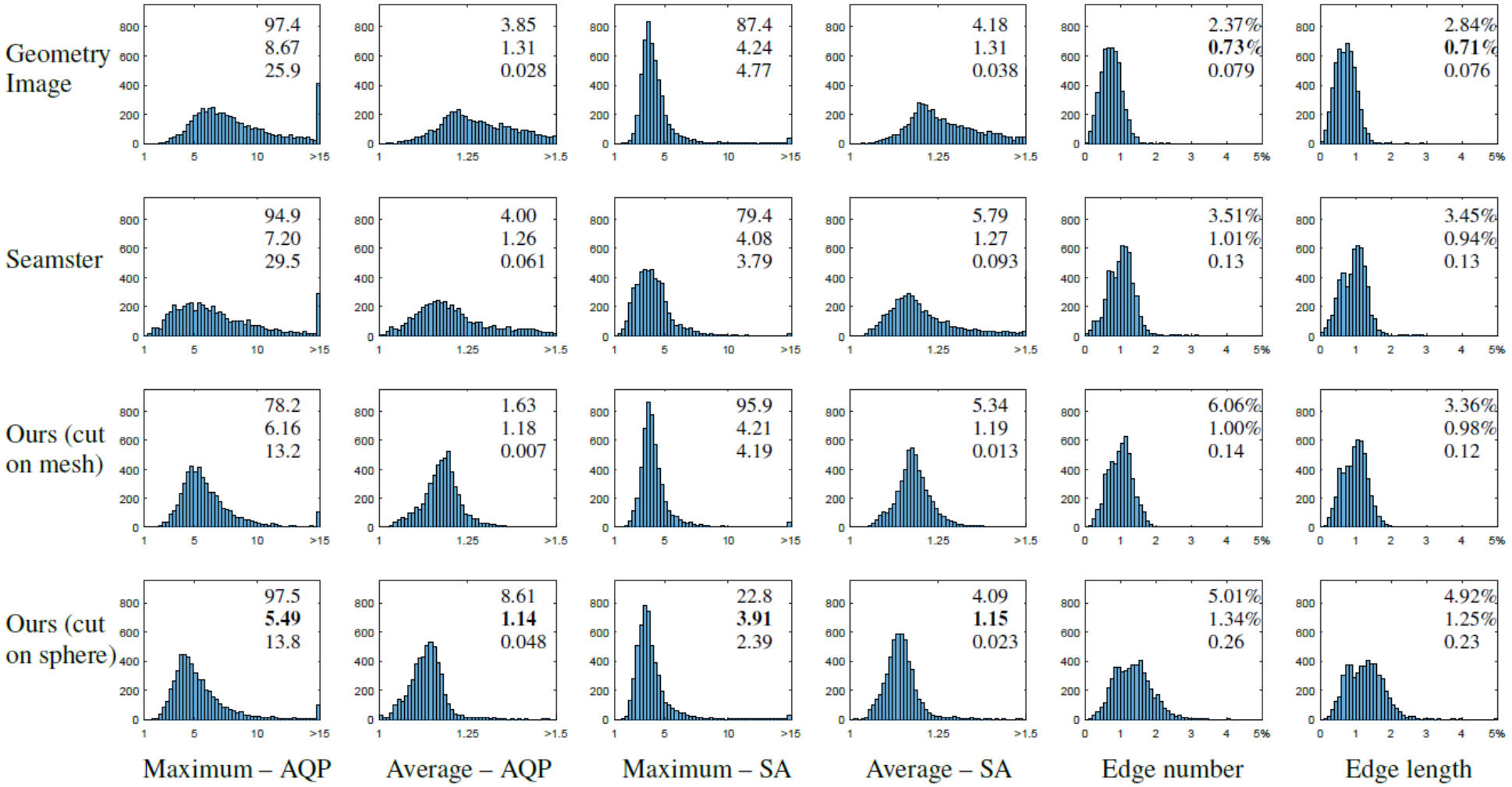
Average filter



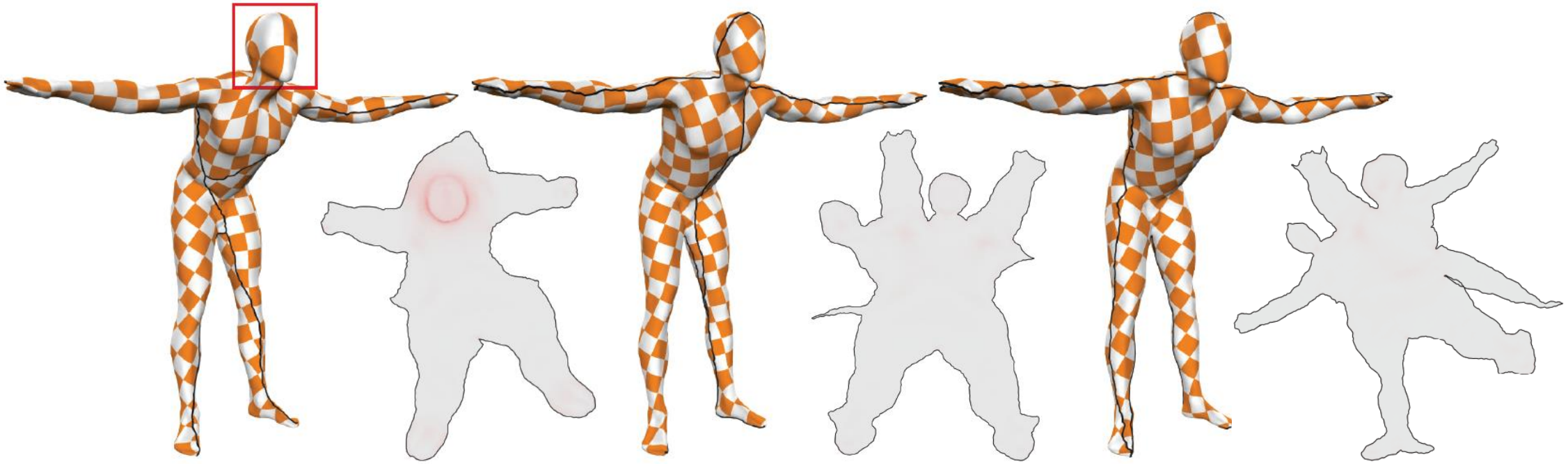
Median filter

Comparisons

Comparison on a 5140 dataset

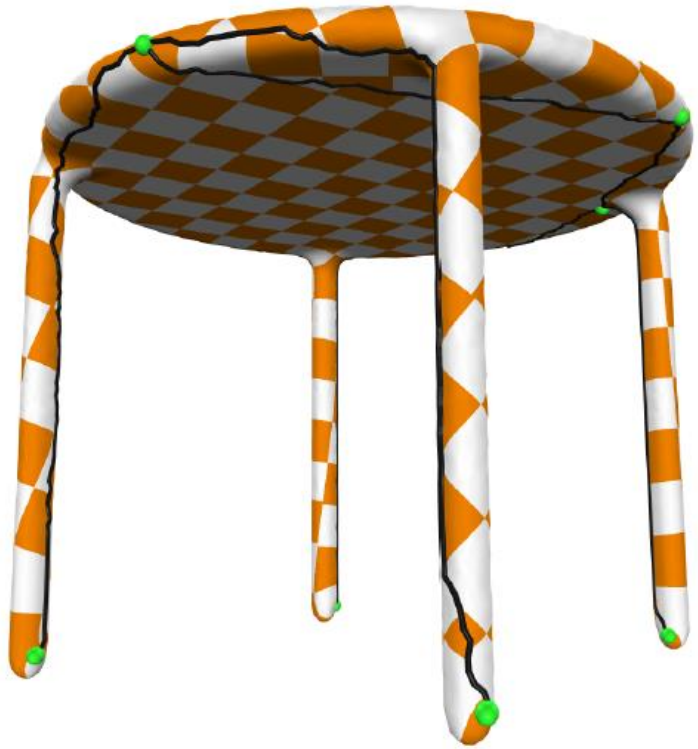


Comparison with Geometry Image [Gu et al., 2002]

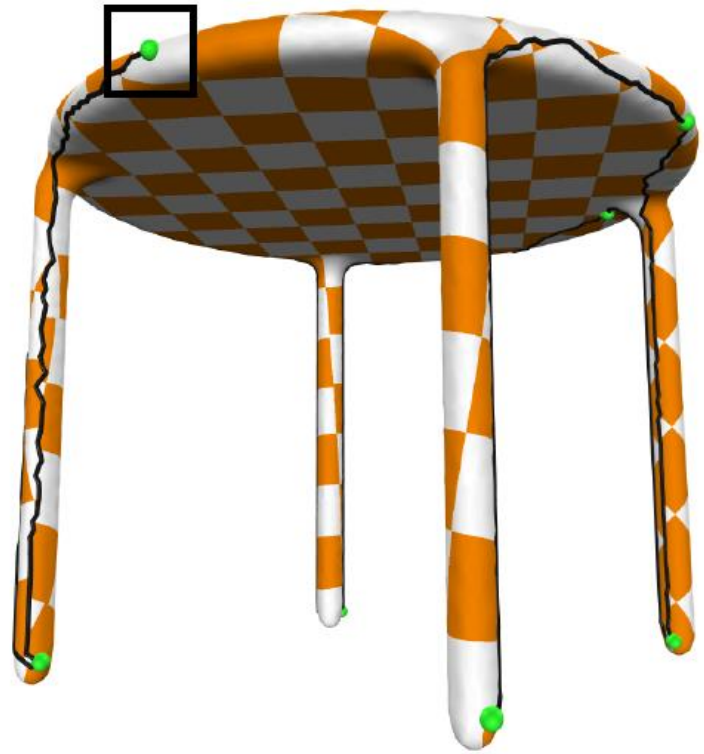


Comparison with Seamster [Shaffer and Hart, 2002]

(3.81/1.09/0.11)
(1.44%/1.23%)

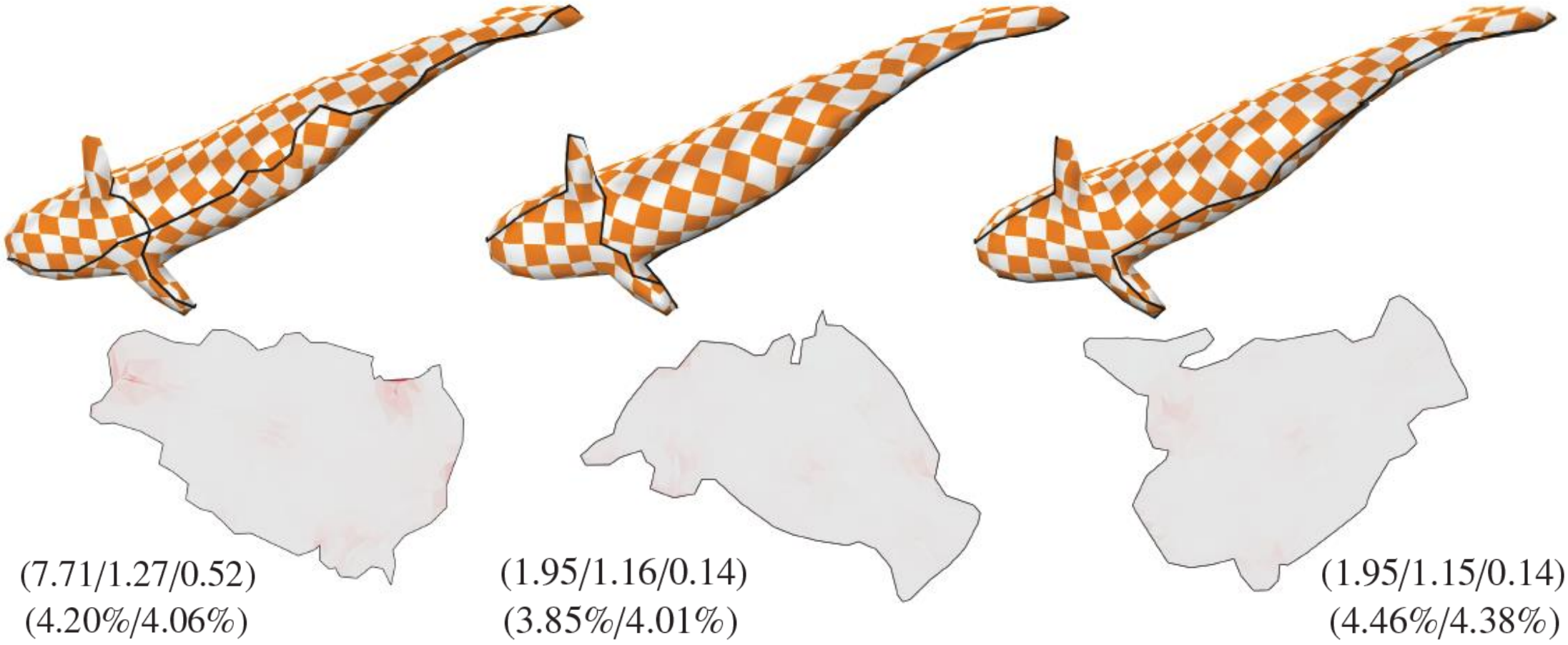


(4.58/1.05/0.13)
(1.26%/1.14%)



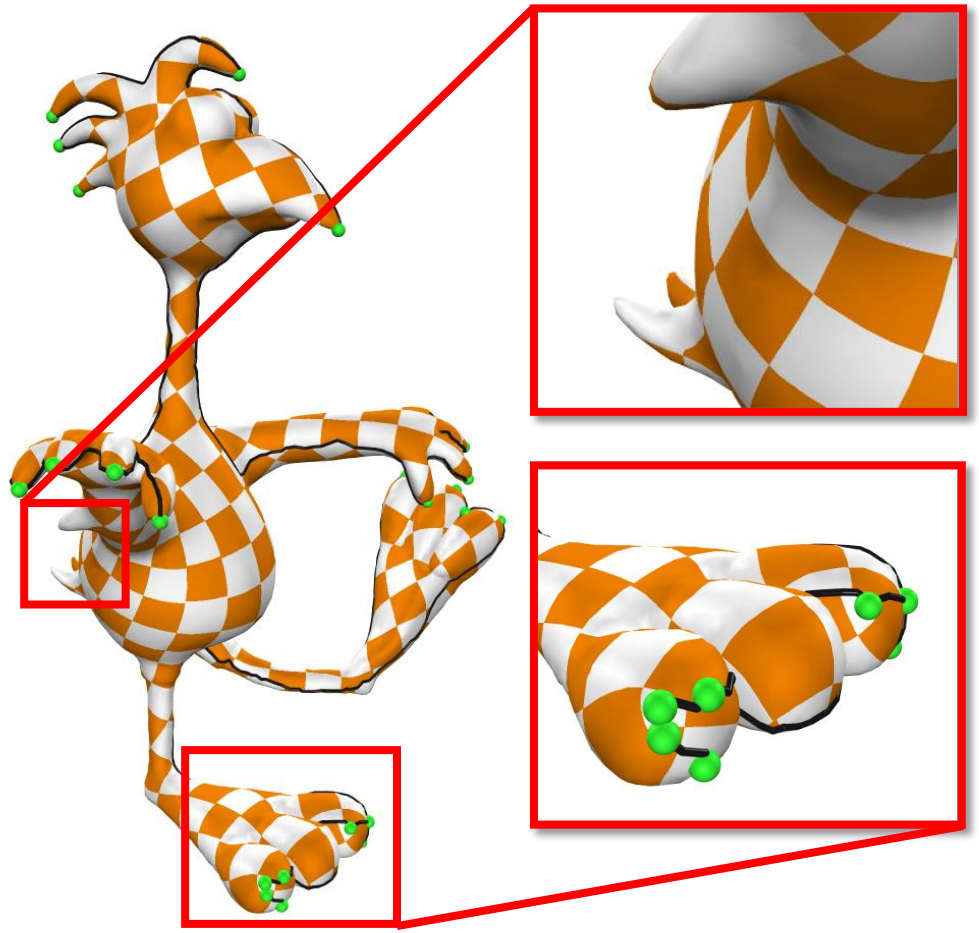
(4.44/1.04/0.09)
(1.68%/1.43%)

Comparison with Autocuts [Poranne et al., 2017]

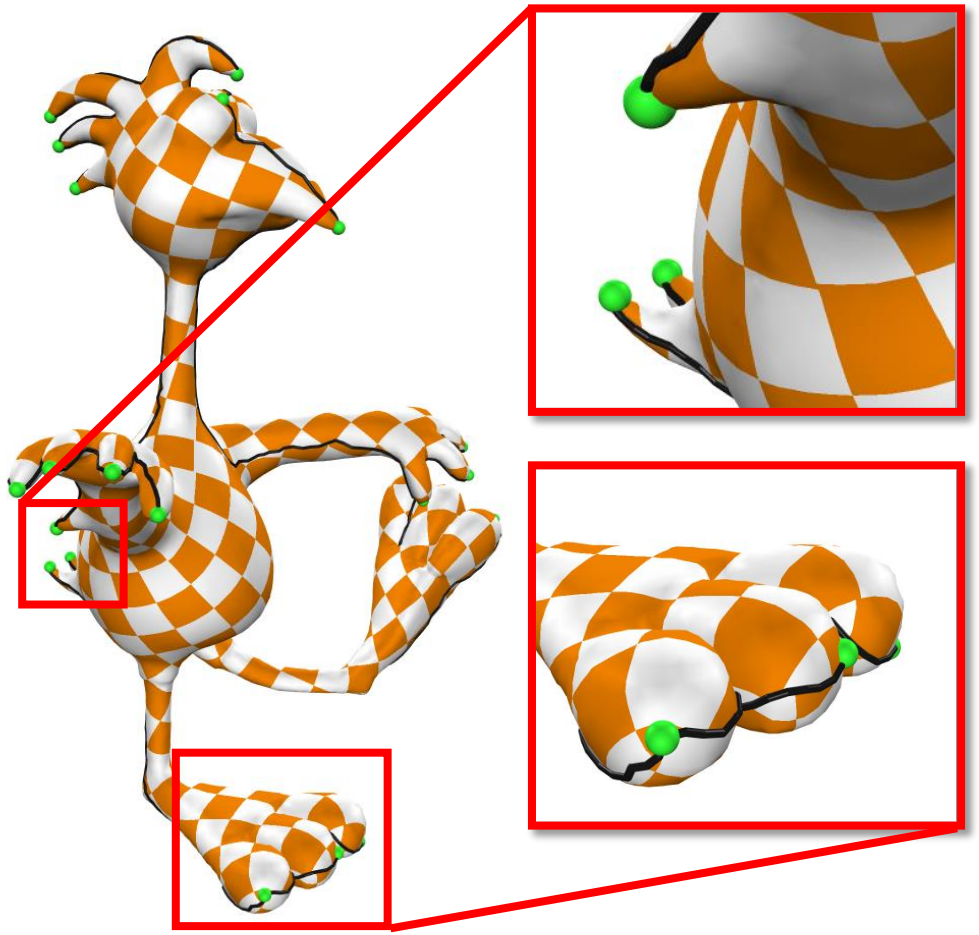


Comparison with Persistence-based Method

[Chazal et al., 2013]



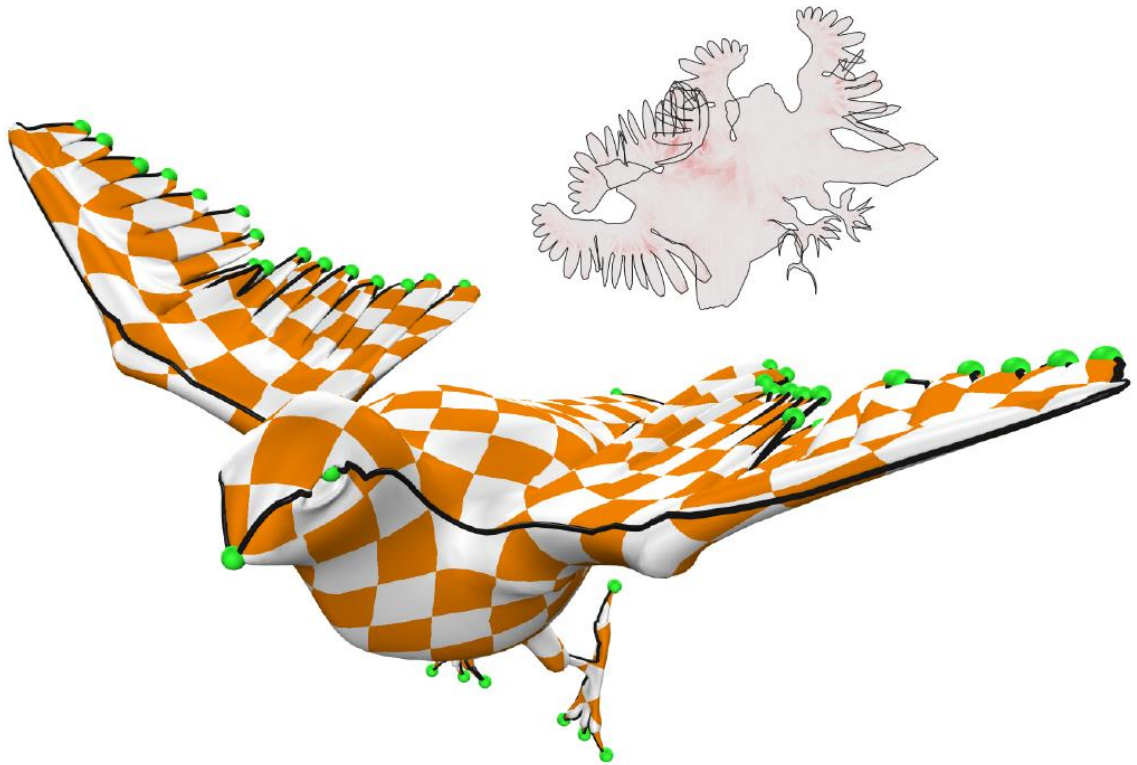
Persistence-based clustering



Our hierarchical clustering

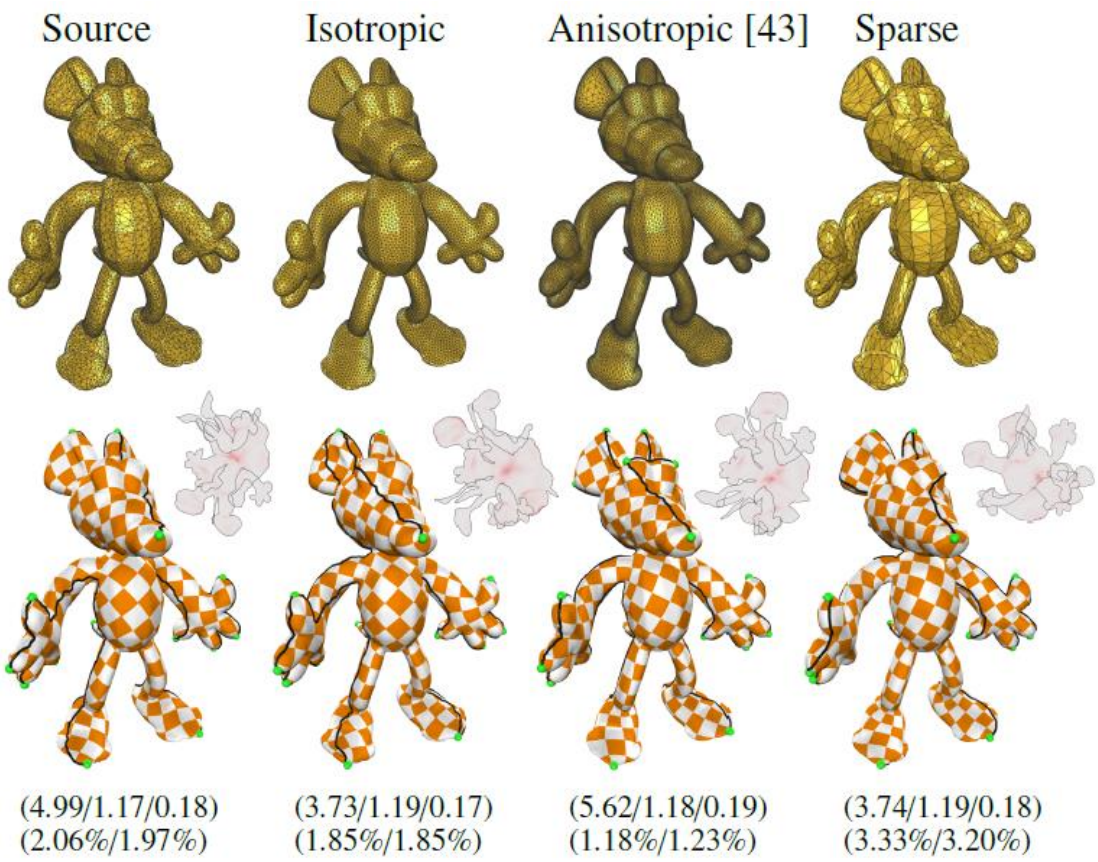
Conclusion

- We present a sphere-based method for constructing high-quality cuts…
  - ACAP spherical parameterization
  - Hierarchical clustering
  - Cut on the sphere
- such that the subsequent planar parameterization can have low isometric distortion.



Limitations and Discussions

- Coupled planar parameterizations
- Domains other than the sphere
- Theoretical guarantees
- Tessellations
- Symmetry



Thank you!