Computational Peeling Art Design

Hao Liu, Xiao-Teng Zhang, Xiao-Ming Fu, Zhi-Chao Dong, Ligang Liu

University of Science and Technology of China

Peeling art design

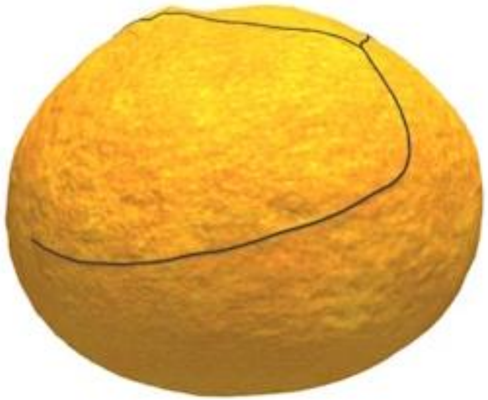
Popular art form

Peeling art examples

Yoshihiro Okada’s method

Peeling art design problem

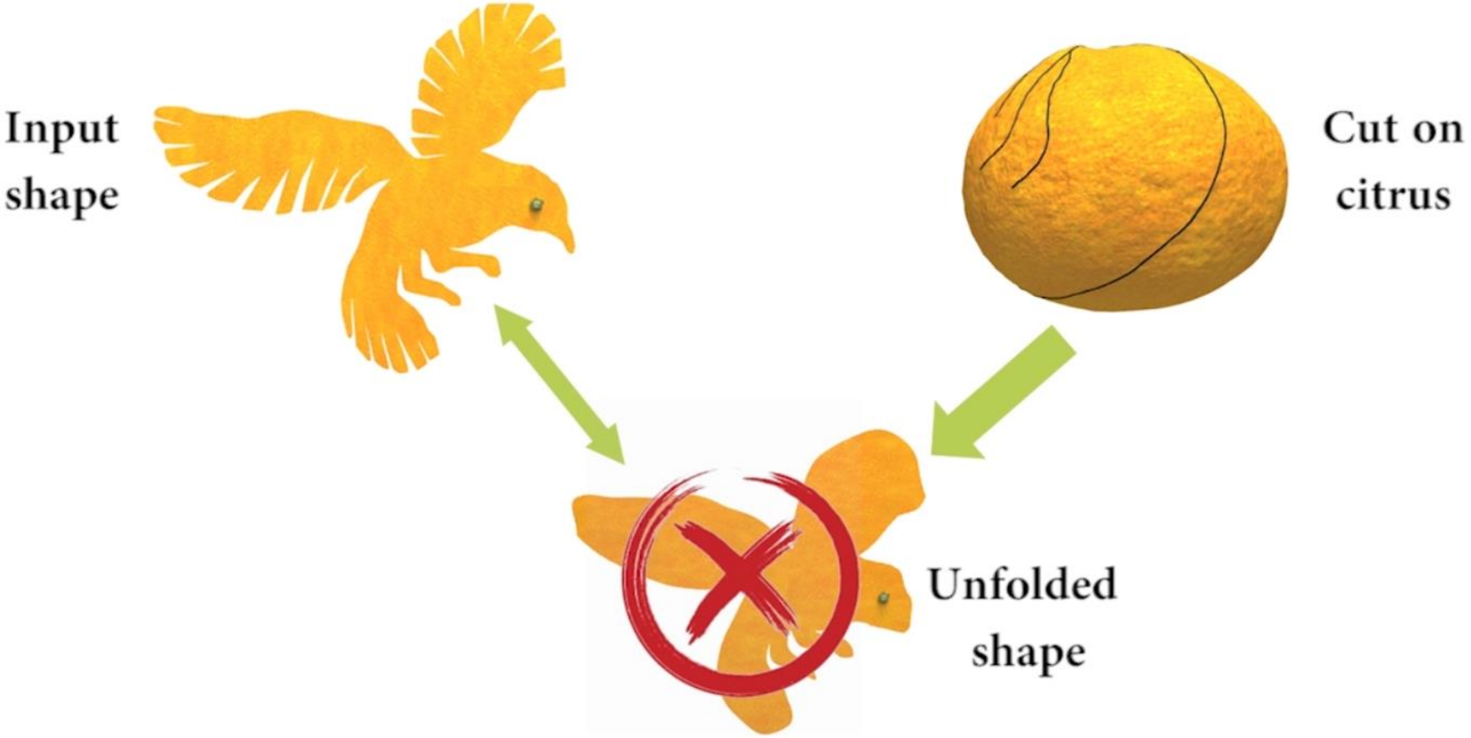
Input shape



Cut on citrus

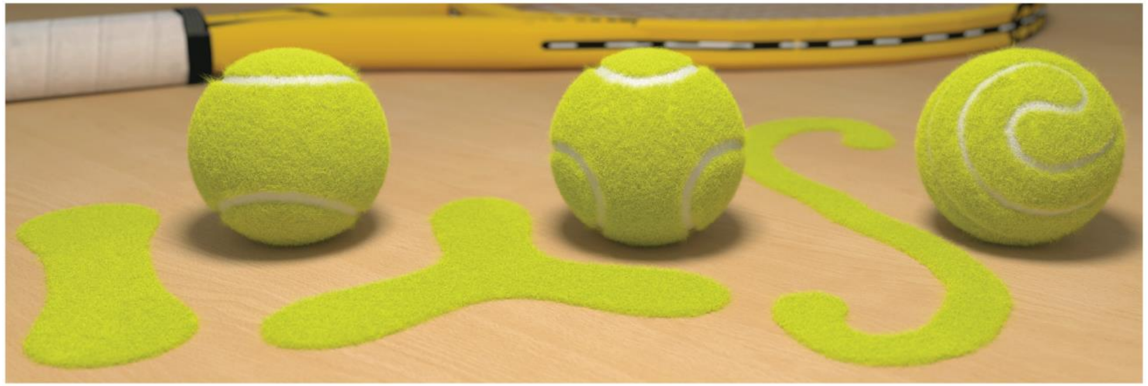
Challenges of the computational method

- Non-trivial to optimize the similarity
- Unsuitable input shape



Existing work: cut generation

- Minimum spanning tree method [Chai et al. 2018; Sheffer 2002; Sheffer and Hart 2002]
- Mesh segmentation approaches [Julius et al. 2005; Lévy et al. 2002; Sander et al. 2002, 2003; Zhang et al. 2005; Zhou et al. 2004]
- Simultaneous optimization [Li et al. 2018; Poranne et al.2017]
- Variational method [Sharp and Crane 2018]

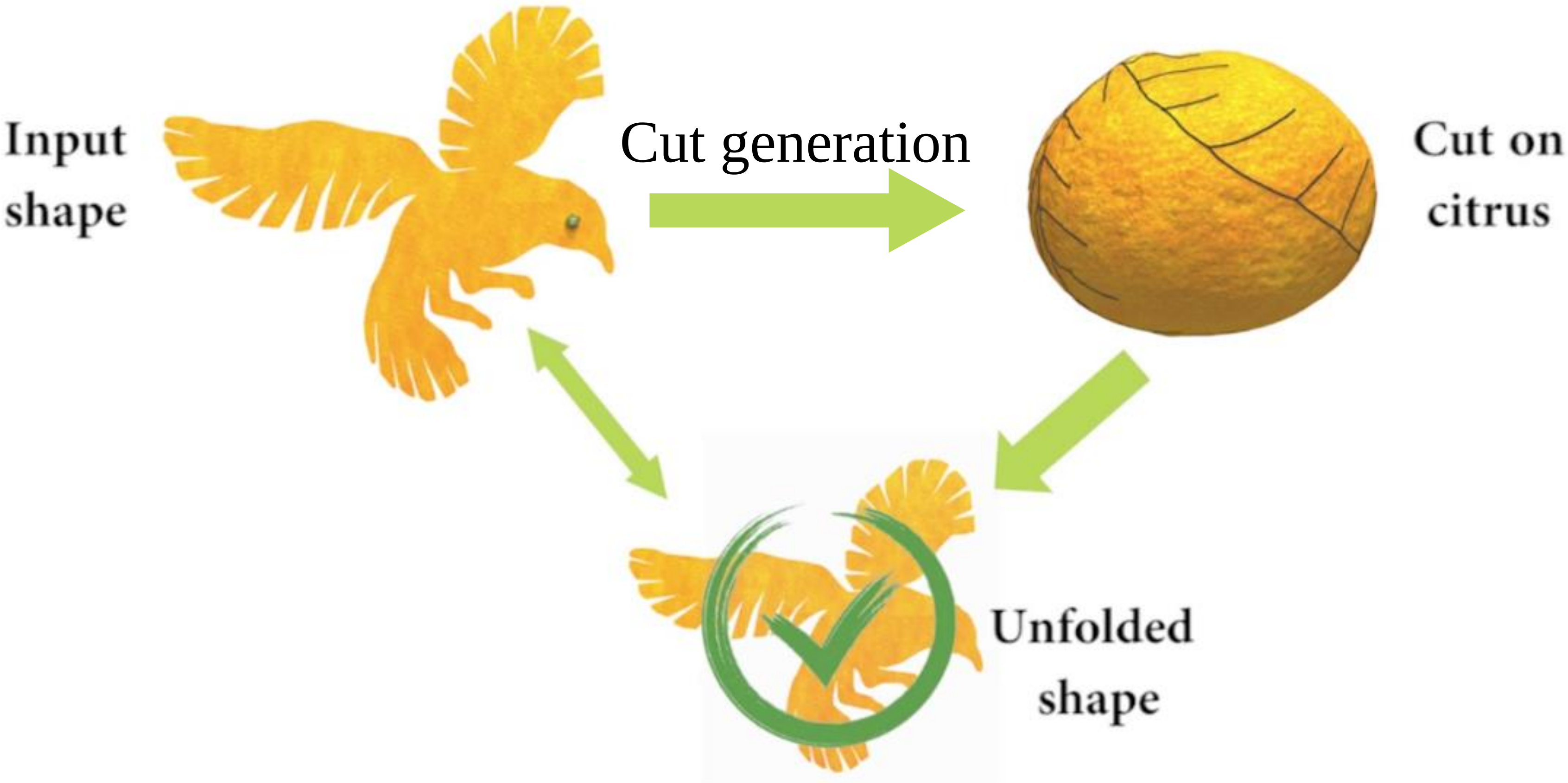


Existing work: cut generation

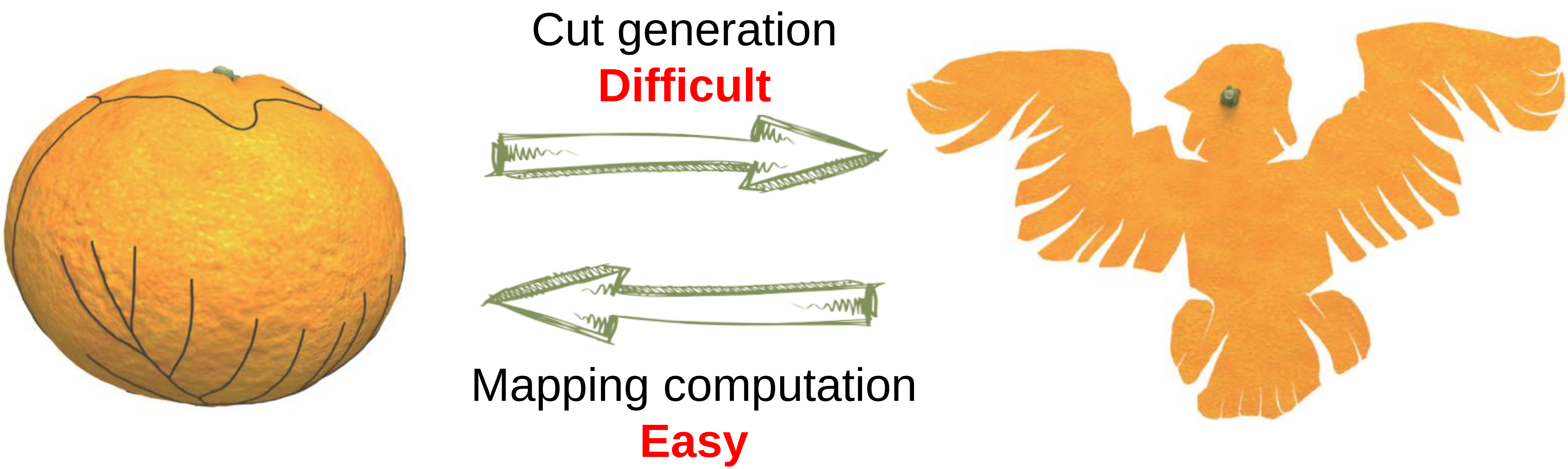
- Minimum spanning tree method [Chai et al. 2018; Sheffer 2002; Sheffer and Hart 2002]
- Mesh segmentation approaches [Julius et al. 2005; Lévy et al. 2002; Sander et al. 2002, 2003; Zhang et al. 2005; Zhou et al. 2004]
- Simultaneous optimization [Li et al. 2018; Poranne et al.2017]
- Variational method [Sharp and Crane 2018]

unfolded shapes ≠ input shapes

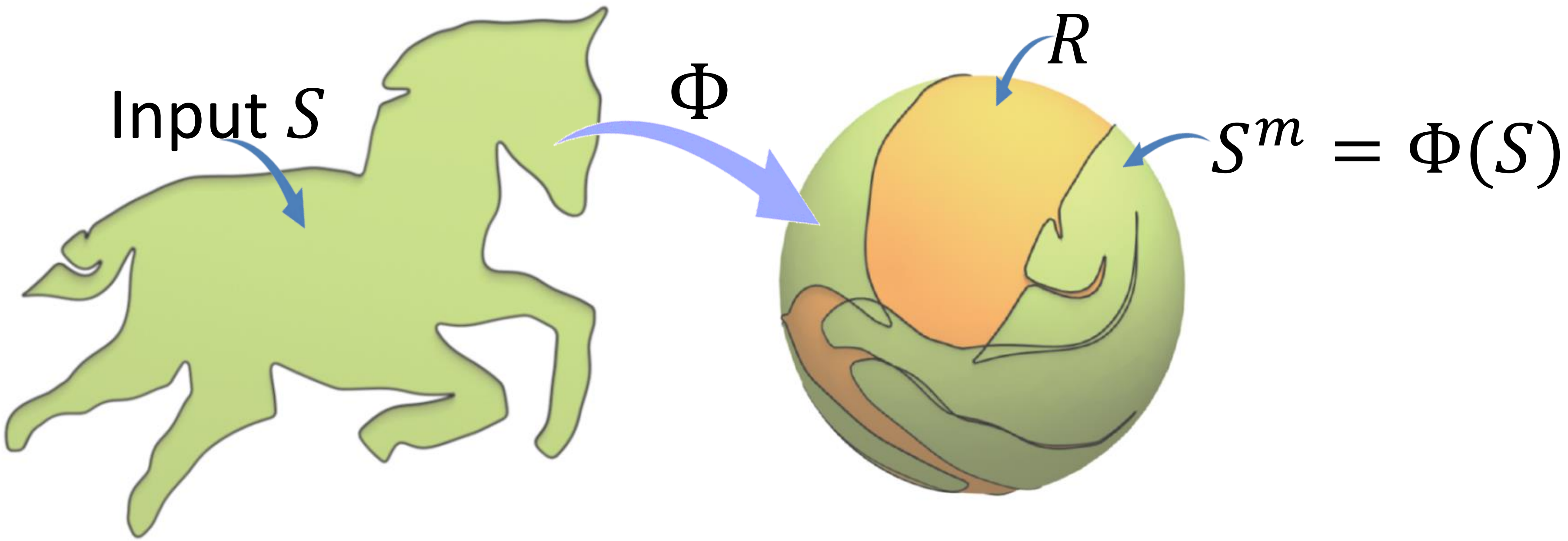
Our approach



Key idea



Mapping computation



Two goals:

1. Low isometric distortion
2. Area of R approaches zero

$$\min E_{iso}(S^m, S) + wE_{shr}(R)$$

Isometric energy

- ARAP distortion metric [Liu et al. 2008]

$$E_{iso}(S^m, S) = \sum_{i=1}^{N_f} Area(f_i)||J_i - R_i||_F^2$$

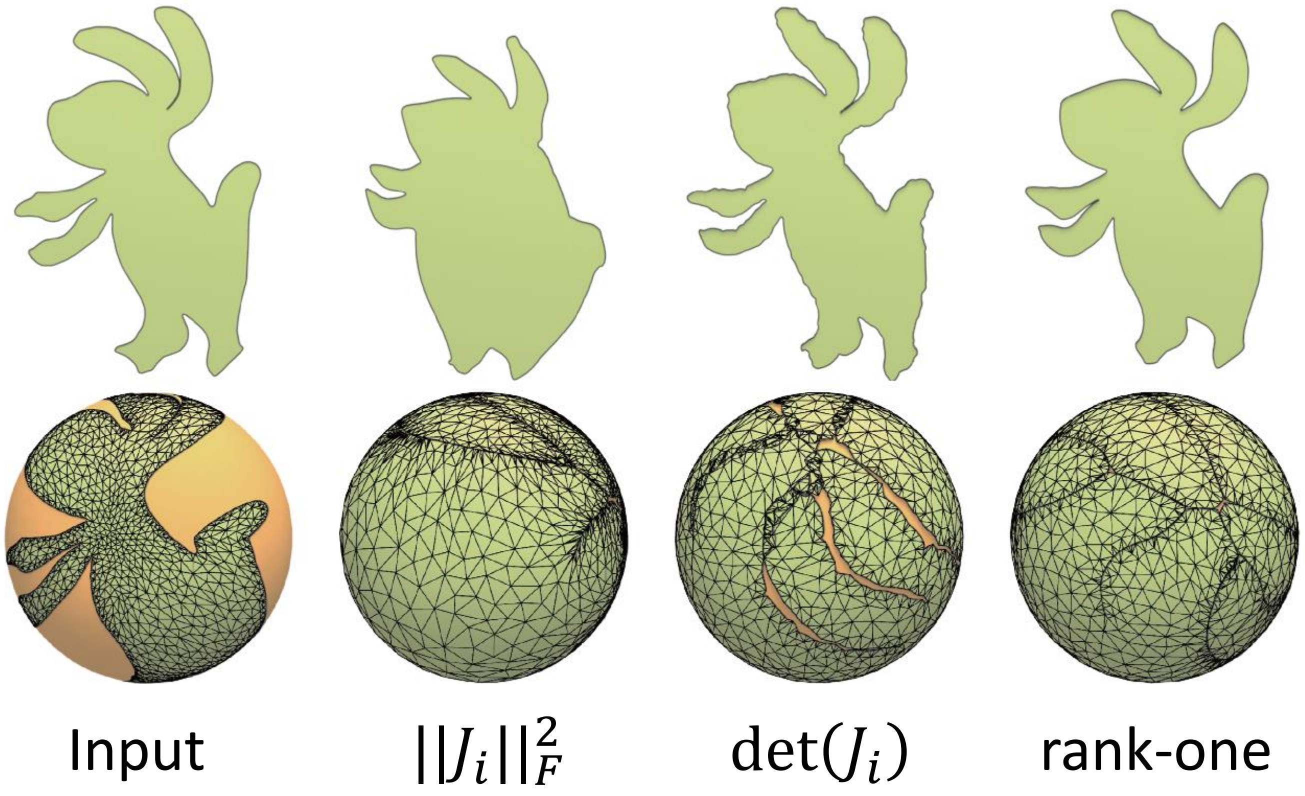
R_i is an orthogonal matrix

Shrink energy

- Our novel rank-one energy

$$E_{shr}(R) = \sum_{i=1}^{N_{R_f}} Area(t_i)||J_i - B_i||_F^2$$

B_i is a rank one matrix



- Other choices
  - Frobenius energy $||J_i||_F^2$
  - Determinant energy $\det(J_i)$

Local-global solver

$$\min E_{iso}(S^m, S) + wE_{shr}(R)$$

$$st. \partial R = \partial S^m \text{ and } v^m, v^R \in M$$

Local step：

$$E_{iso}(S^m, S) = \sum_{i=1}^{N_f} Area(f_i)||J_i - R_i||_F^2 \qquad R_i = U_i V_i^T$$

$$E_{shr}(R) = \sum_{i=1}^{N_{R_f}} Area(t_i)||J_i - B_i||_F^2 \qquad B_i = U_i diag(\sigma_i, 0) V_i^T$$

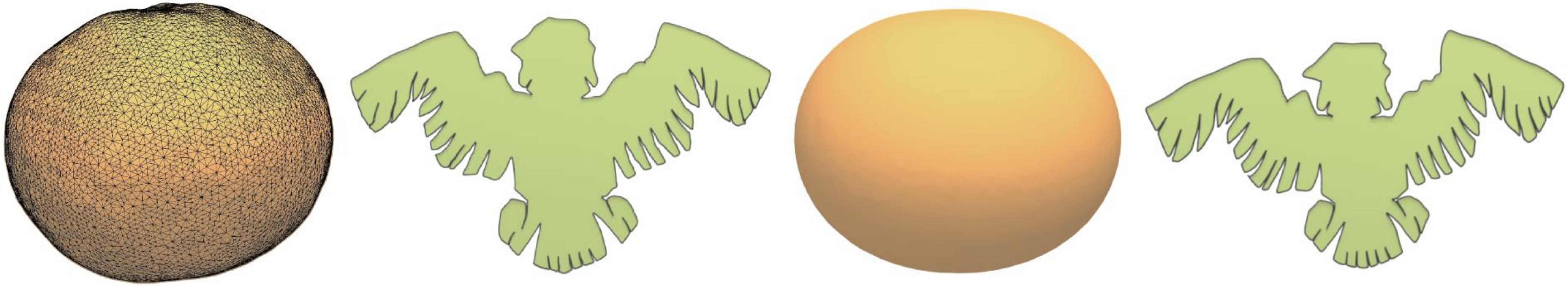
Global step：

$$variables\ \delta v_k\ in \text{ tangent space } v_k^{new} = P(v_k + \delta v_k)$$

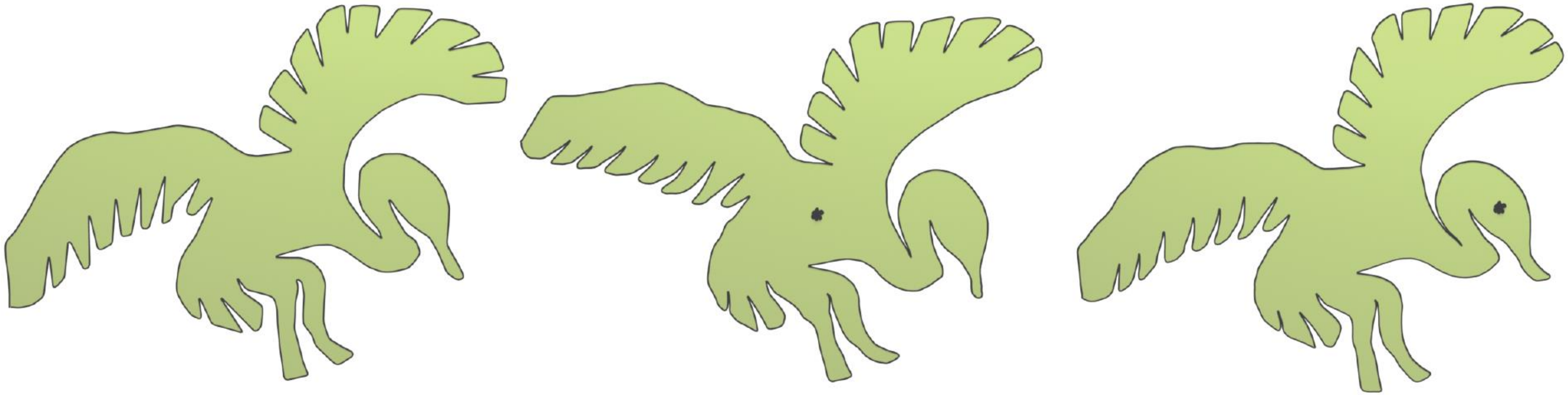
$$\delta v_k\ in\ F_j\ is\ \delta v_k^j = \left(F_k^j\right)^T F_k^v \delta v_k$$

Some details

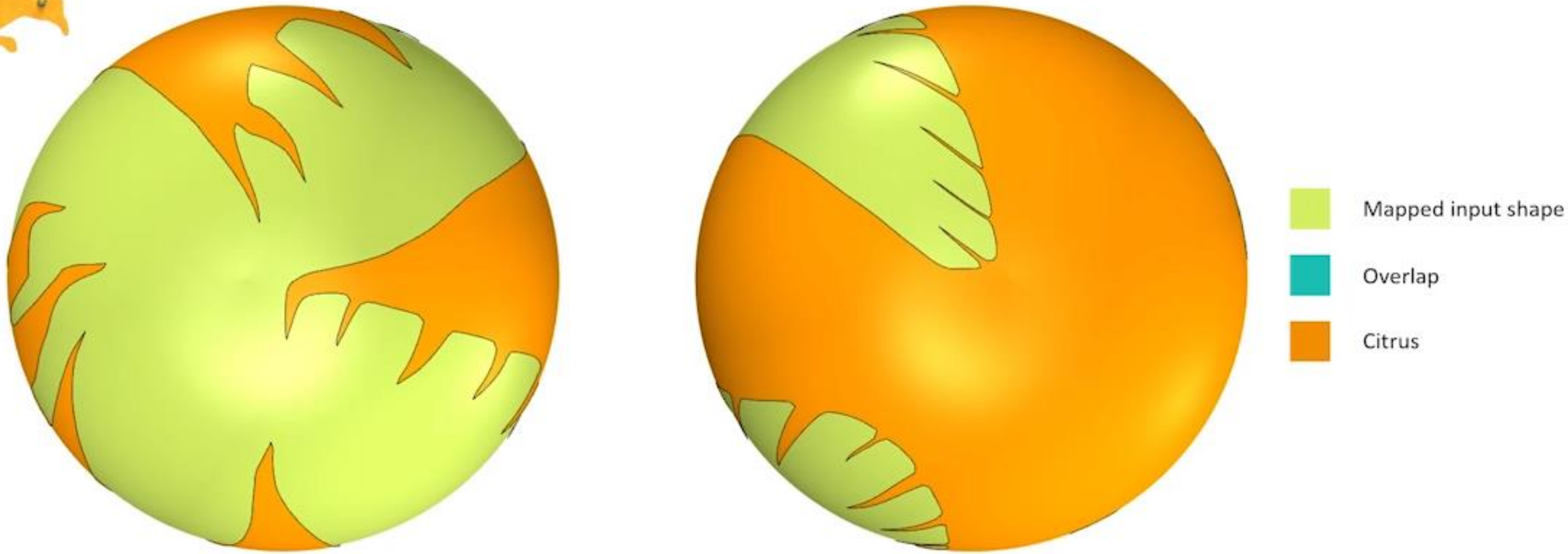
Representations of M



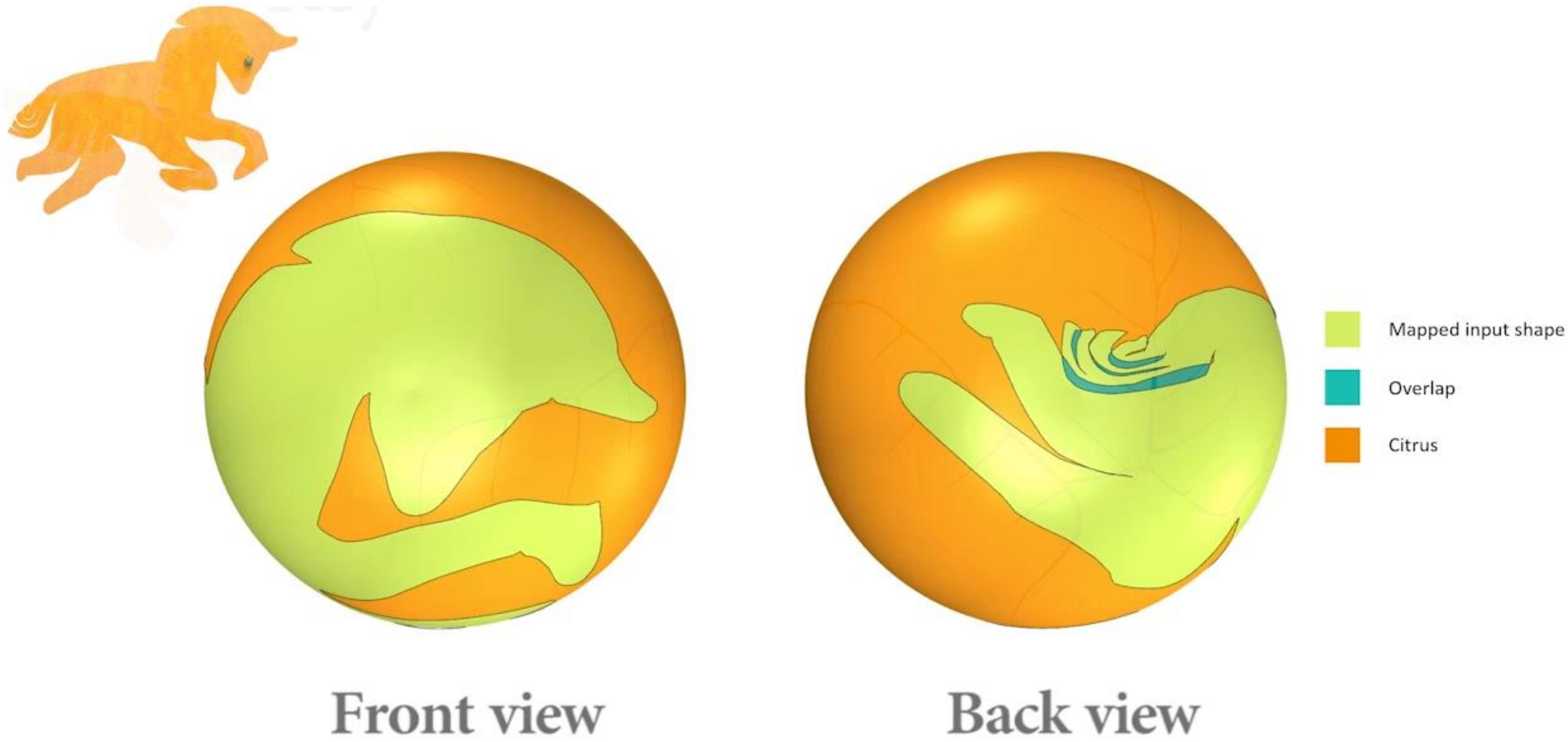
stalk locations



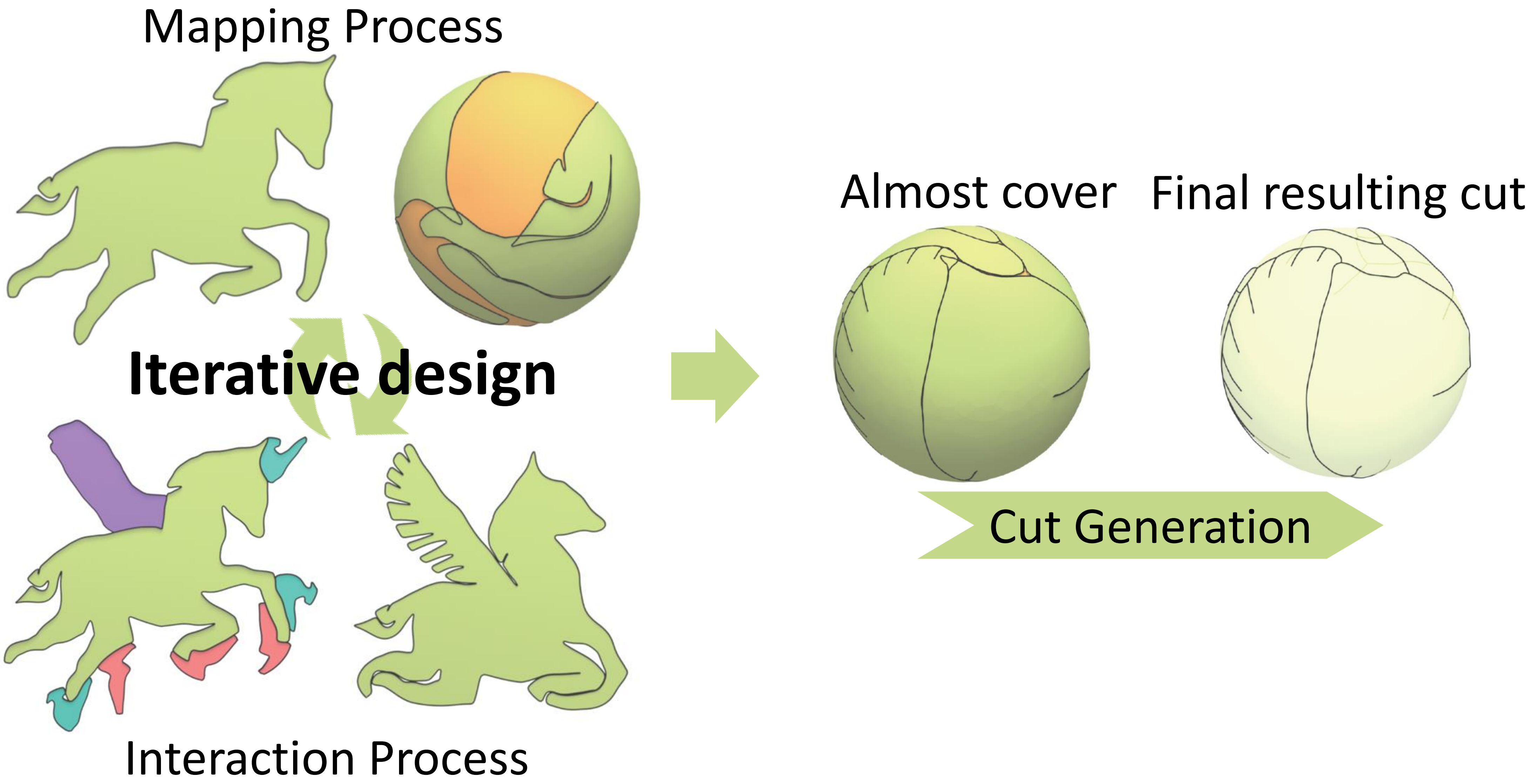
Suitable input



Unsuitable input

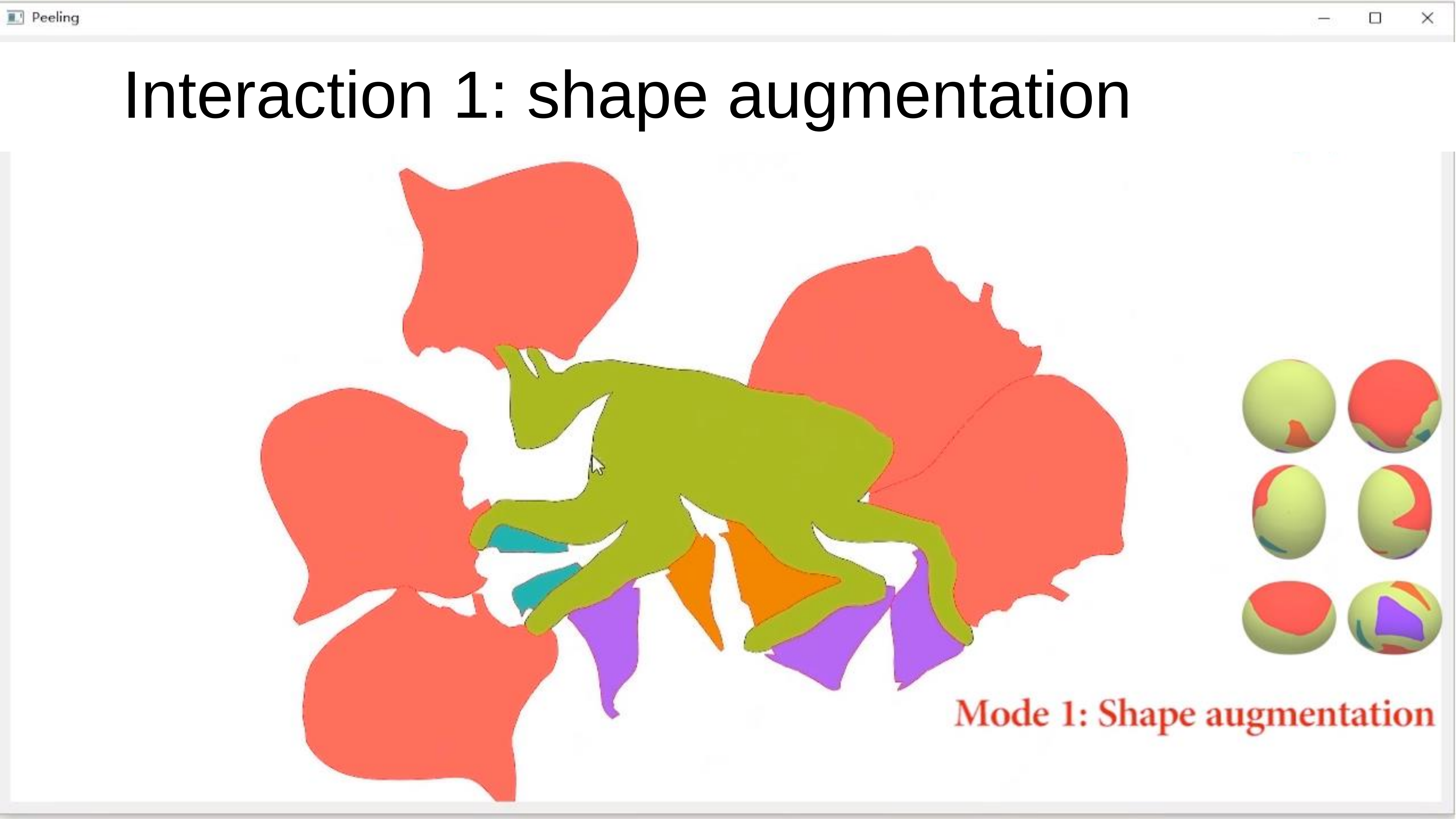


Iterative interaction

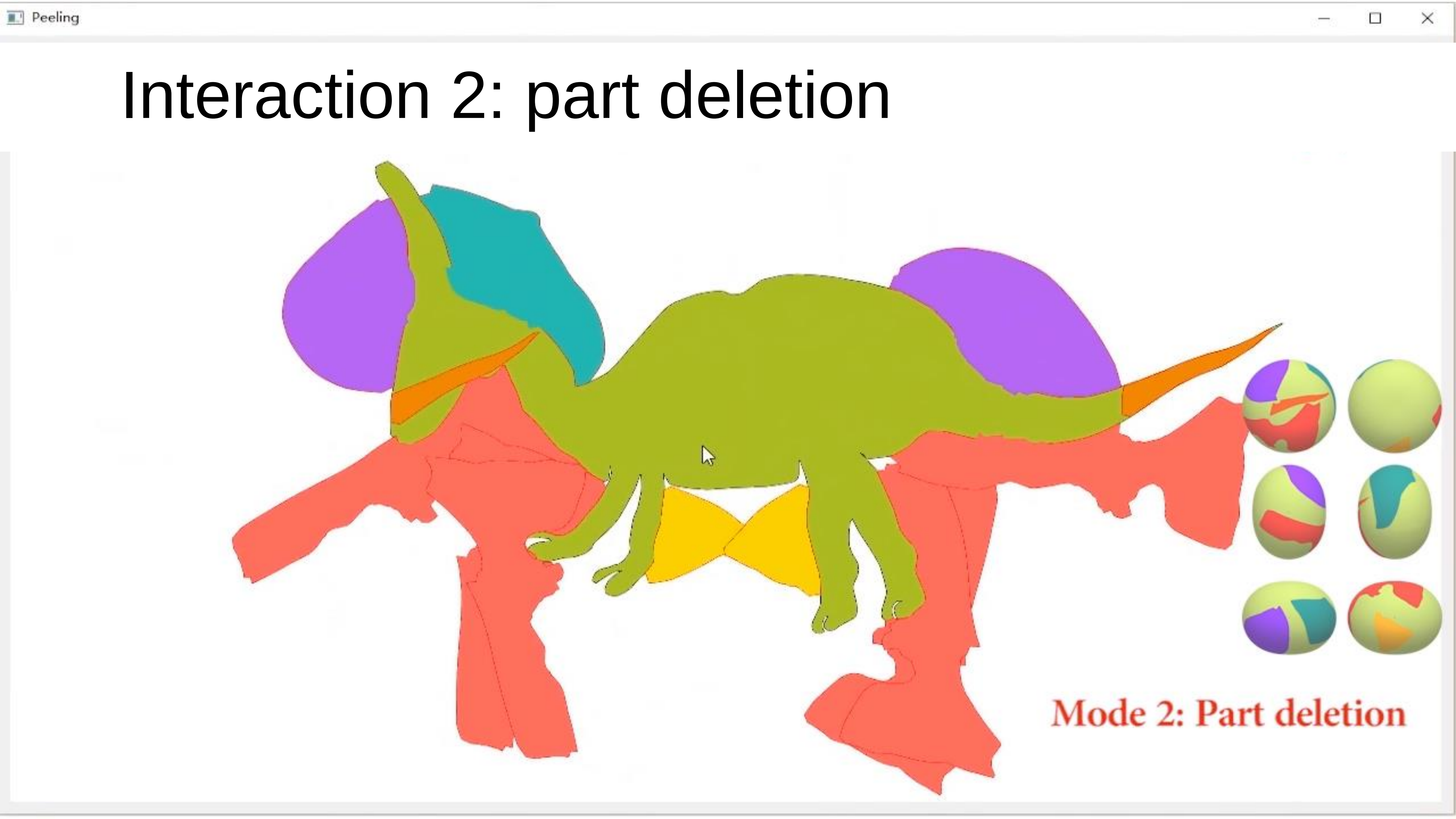


Interaction place

Interaction 1: shape augmentation

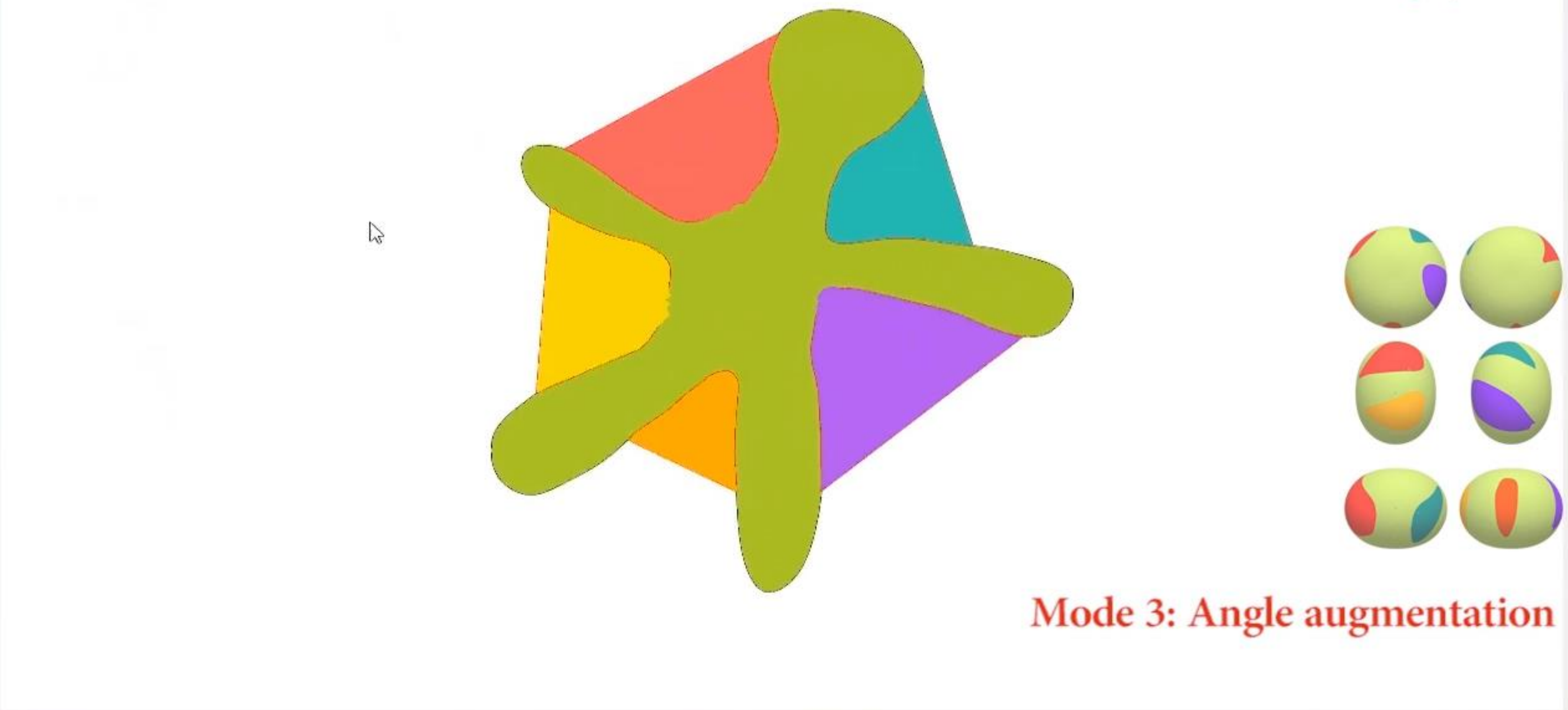


Interaction 2: part deletion

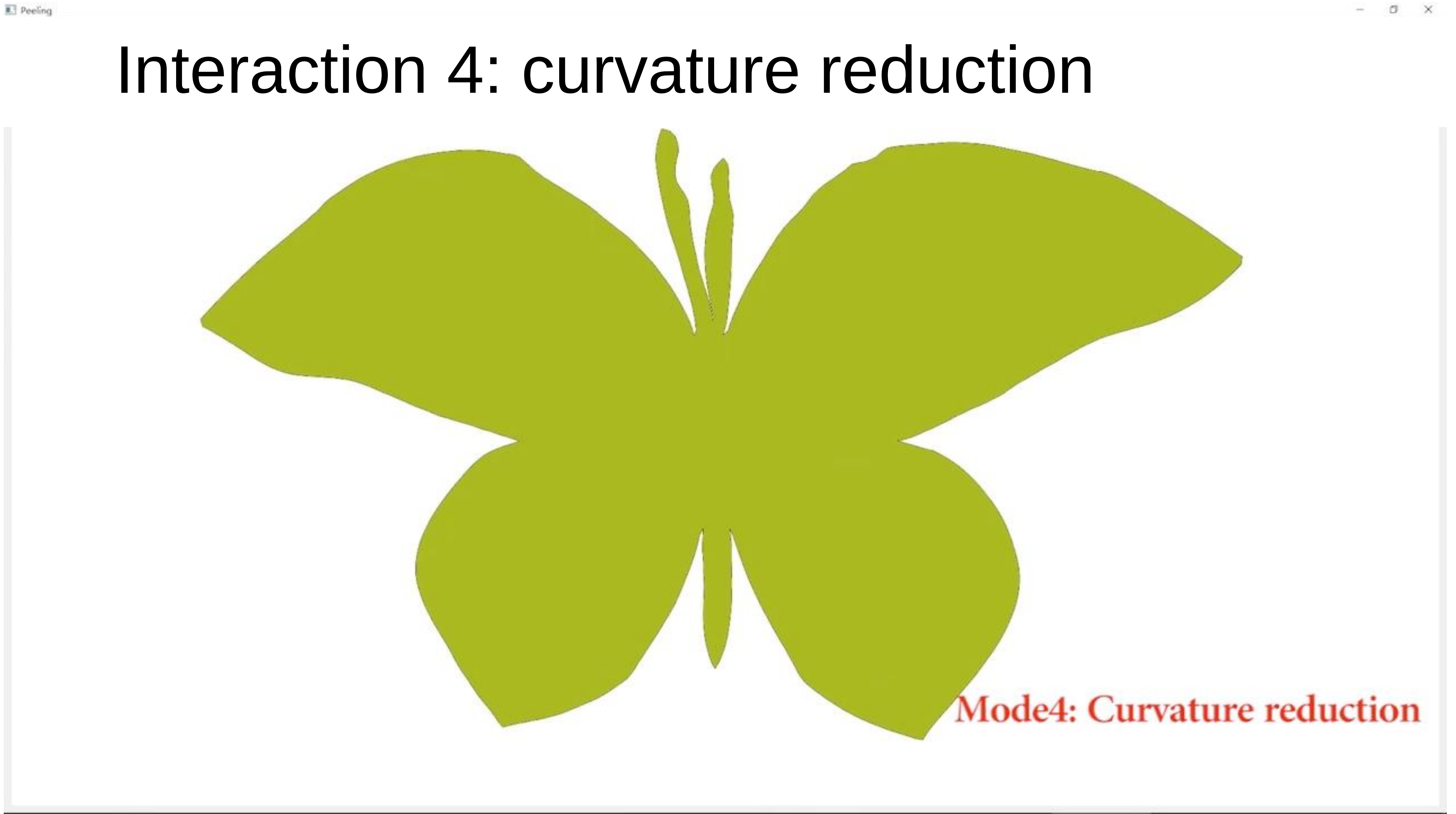


Peeling

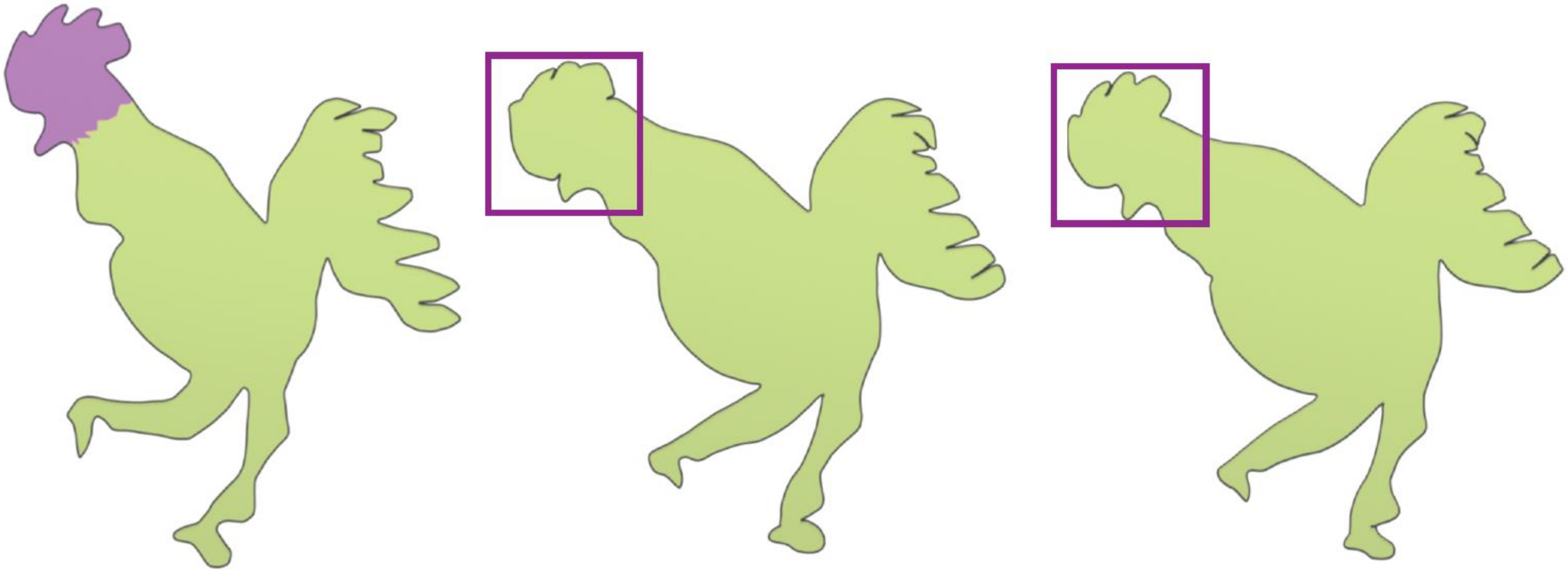
Interaction 3: angle augmentation



Interaction 4: curvature reduction



Interaction 5: pre-processing

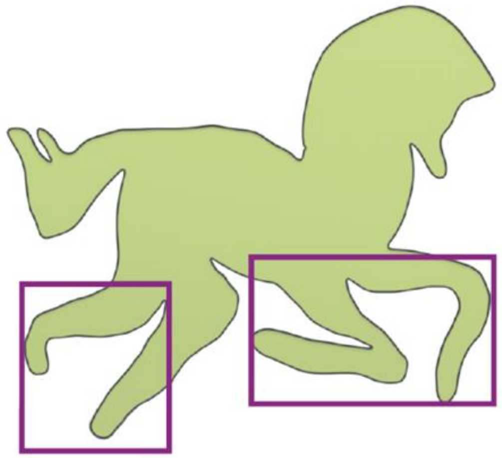


Input
with specify area

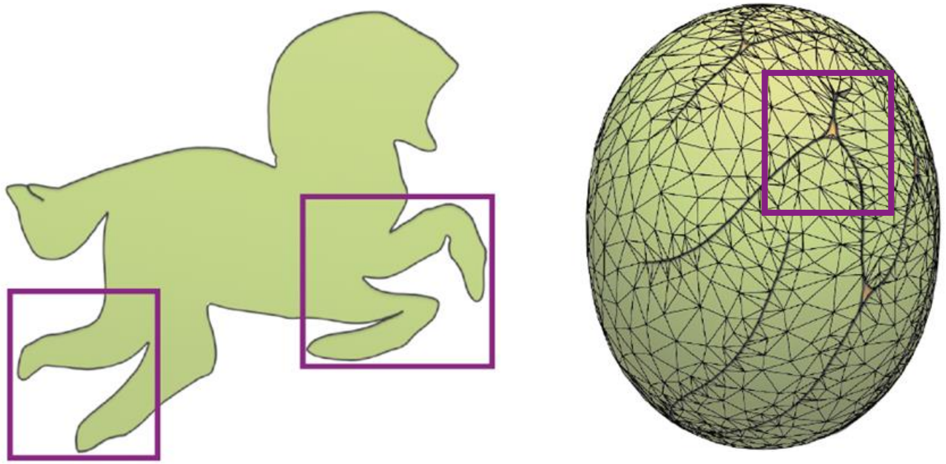
Unprocessed
high distortion

Processed
low distortion

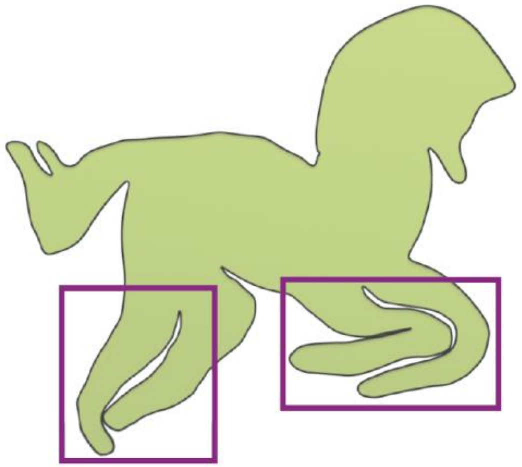
Interaction 5: pre-processing



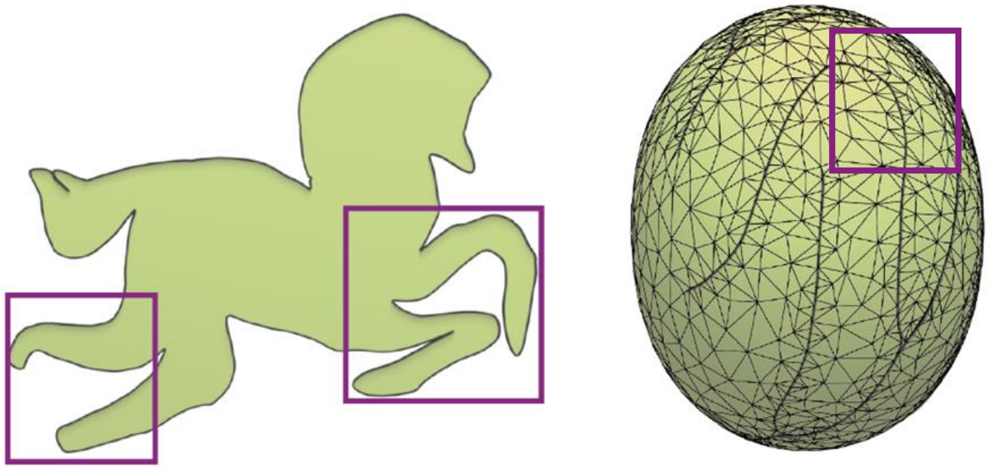
Input with specify area



Unprocessed: high distortion

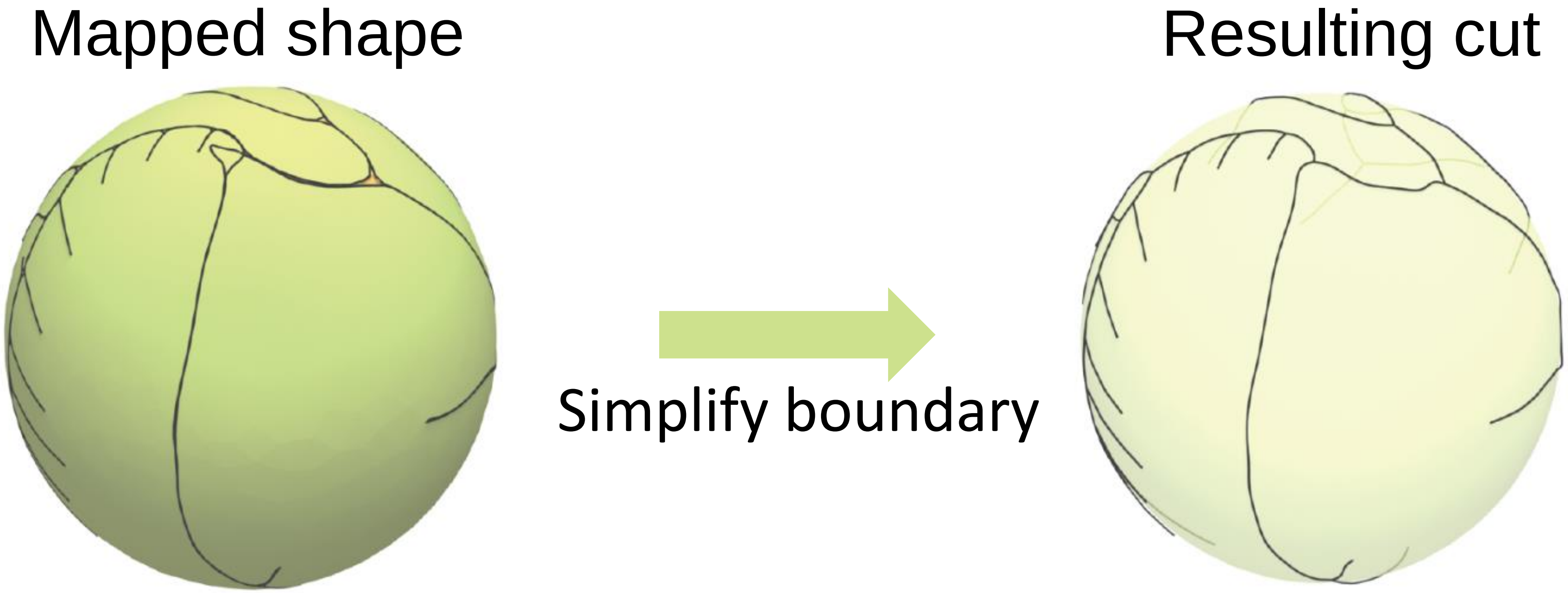


Align to initialize

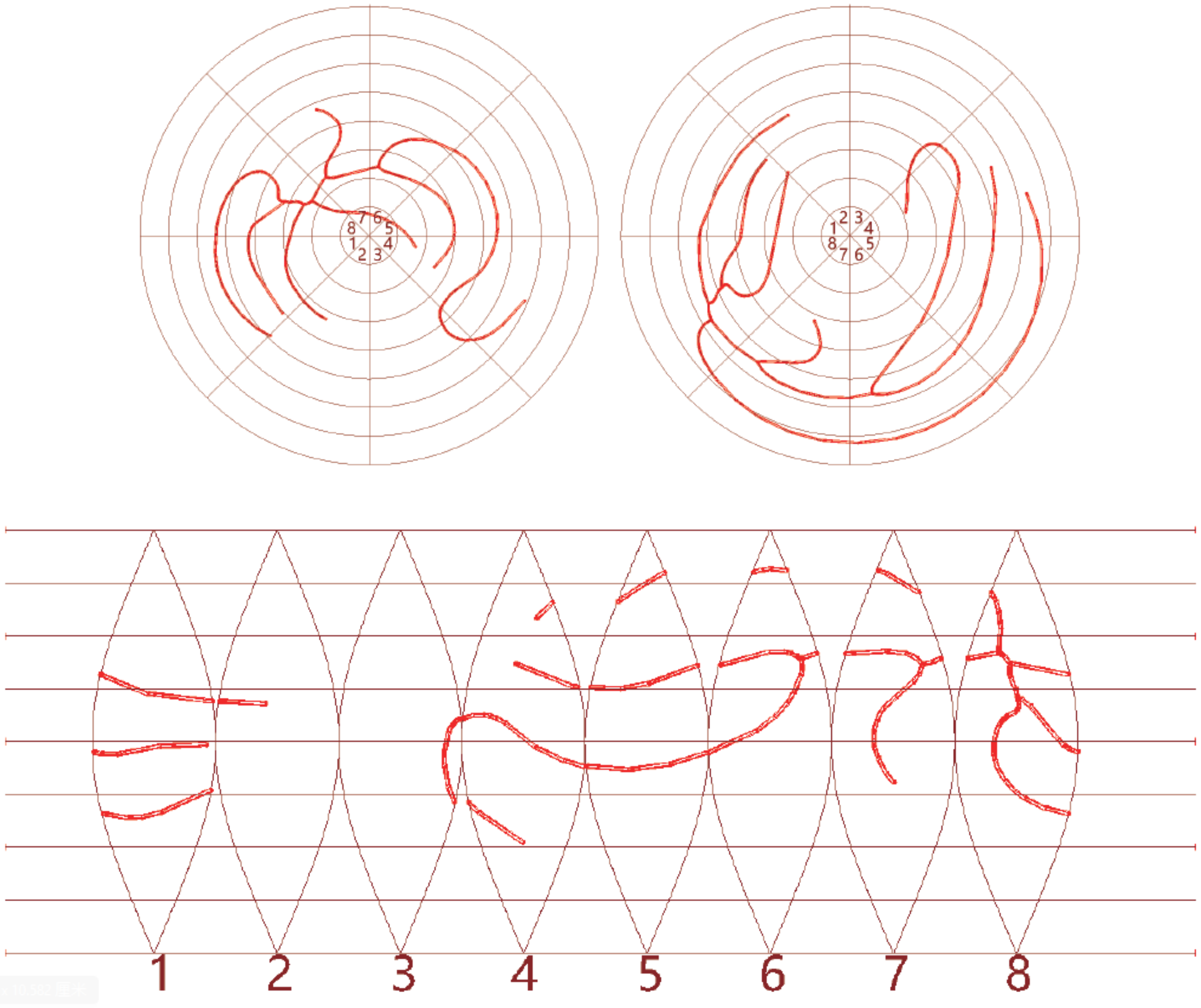


Processed: low distortion

Cut generation



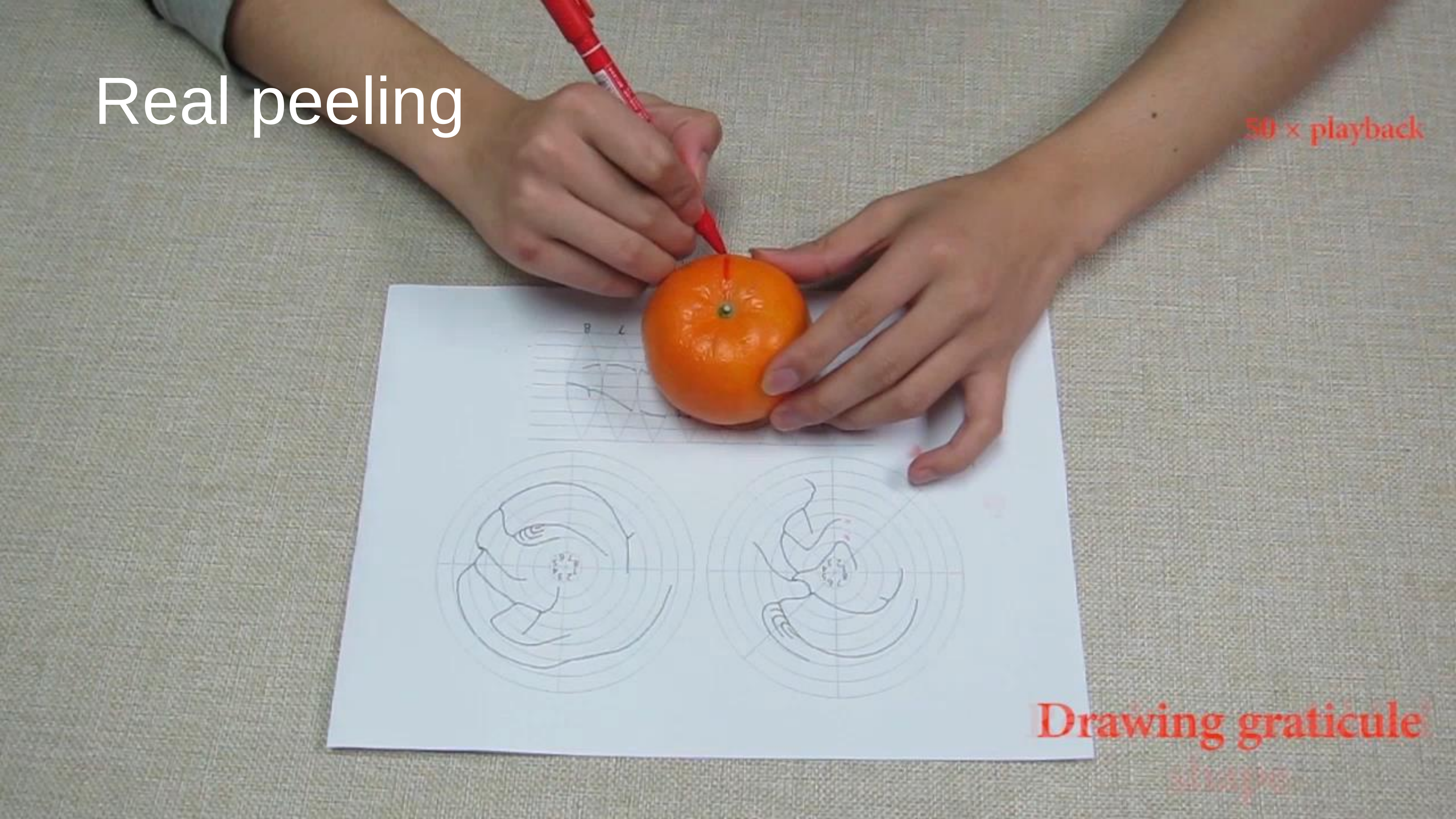
Real peeling



Real design

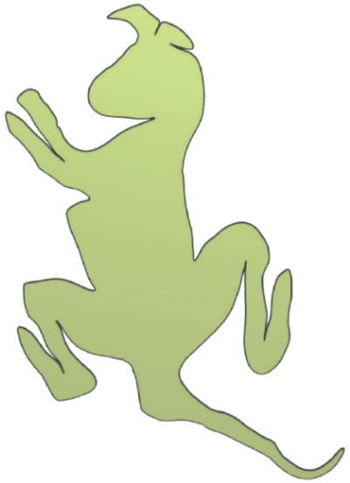
Screen capture
10 × playback

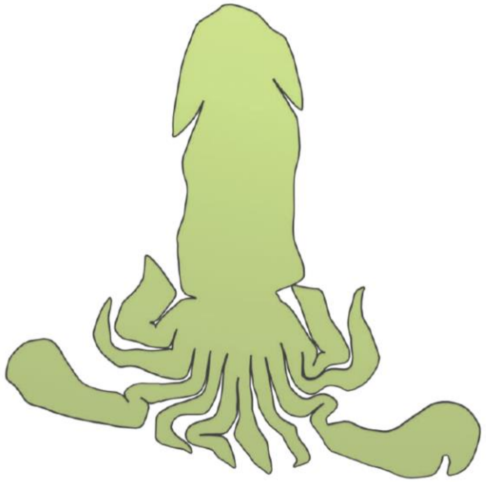
Mapping process

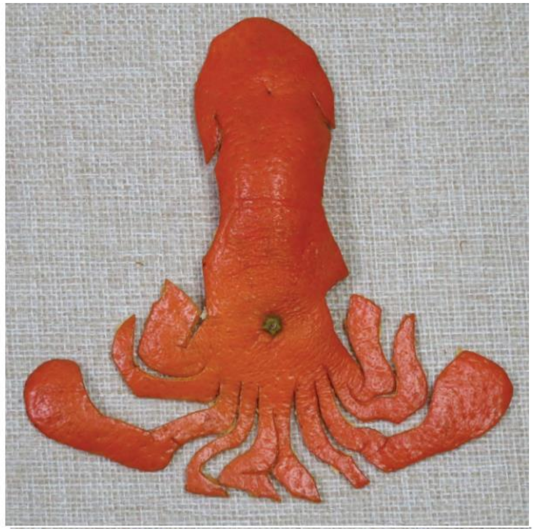

Real peeling
50 × playback
Drawing graticule

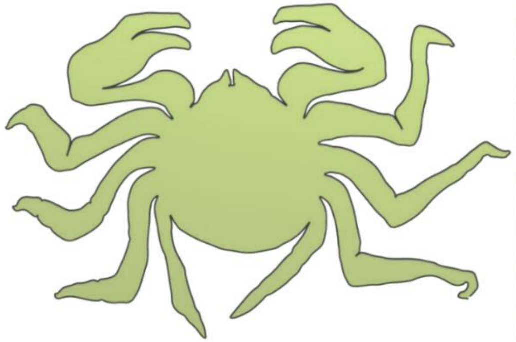
Experiments

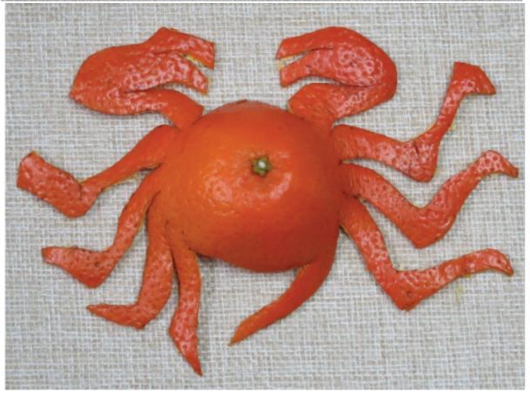
Shapes designed by Yoshihiro Okada

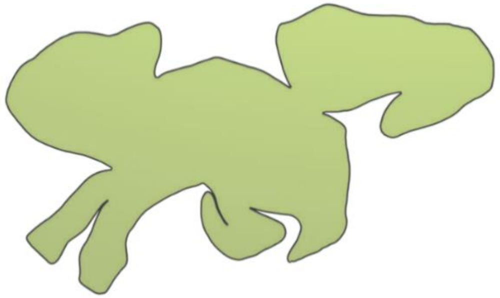


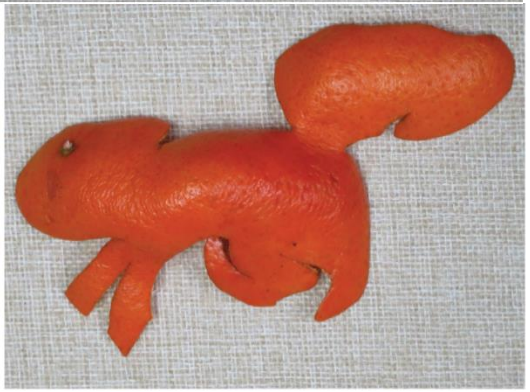












Comparison to Yoshihiro Okada

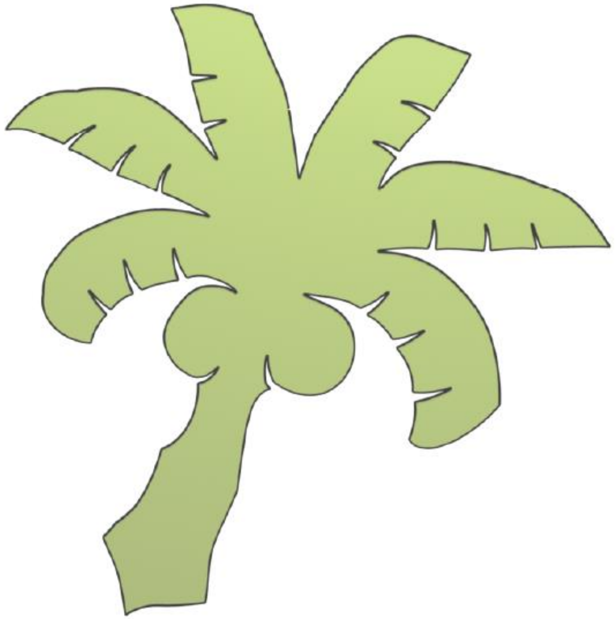
Okada's

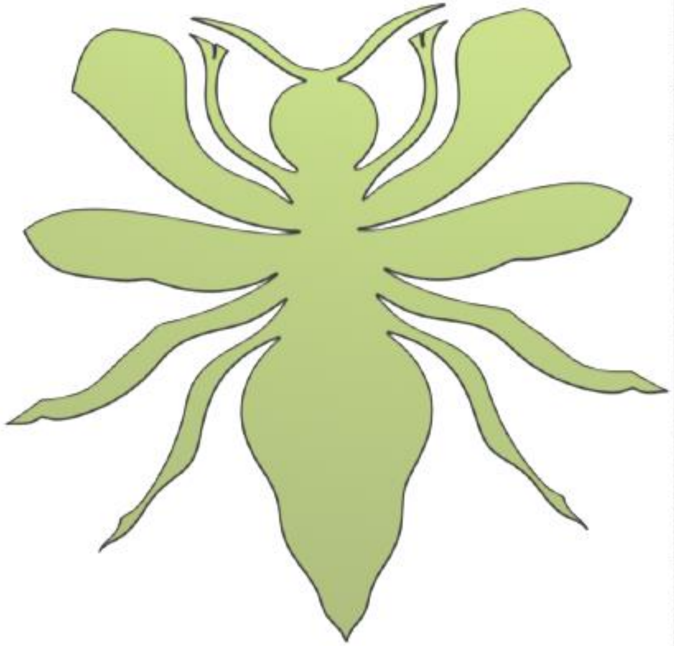
Ours

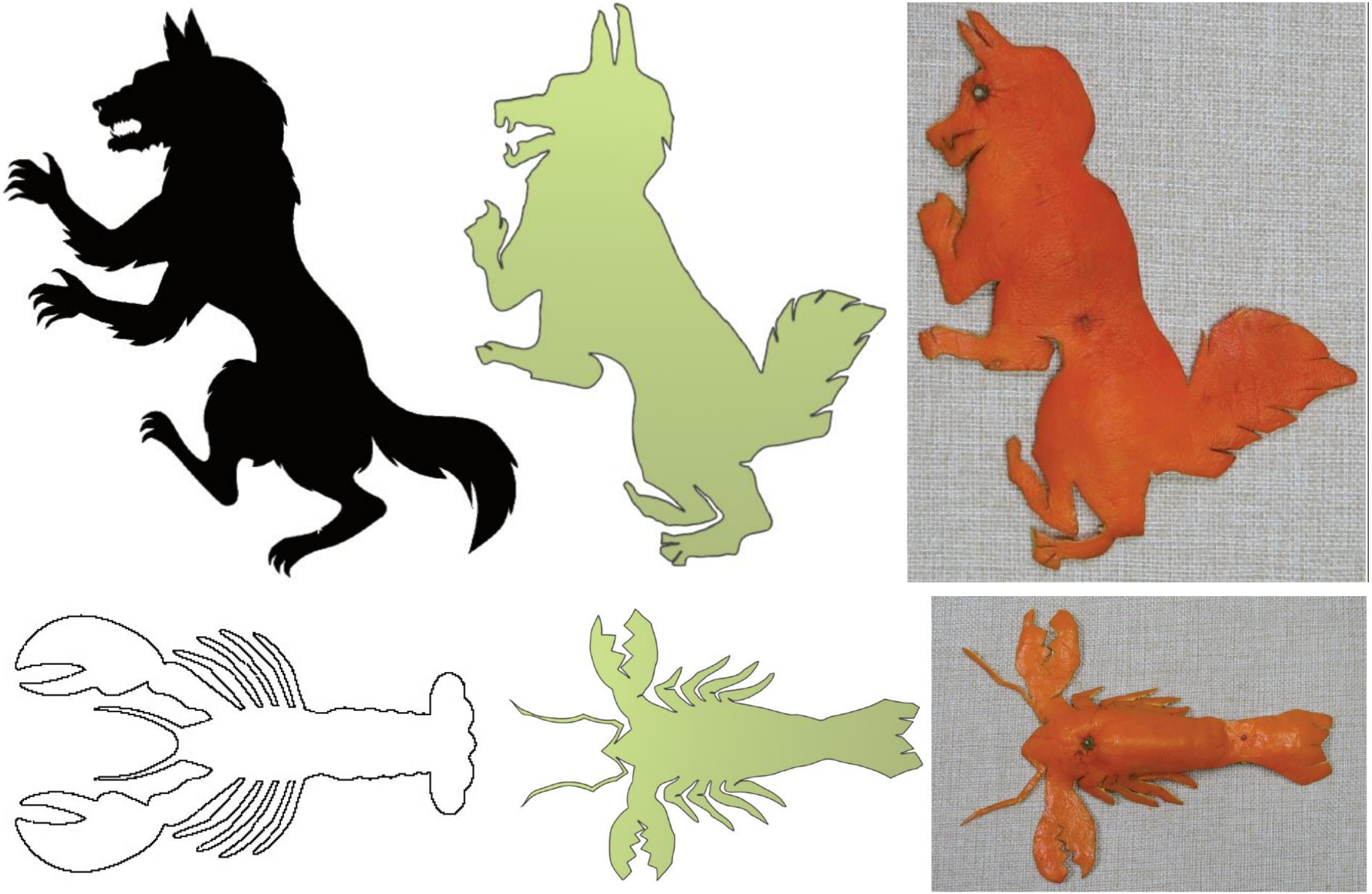
Dove Eagle Shrimp

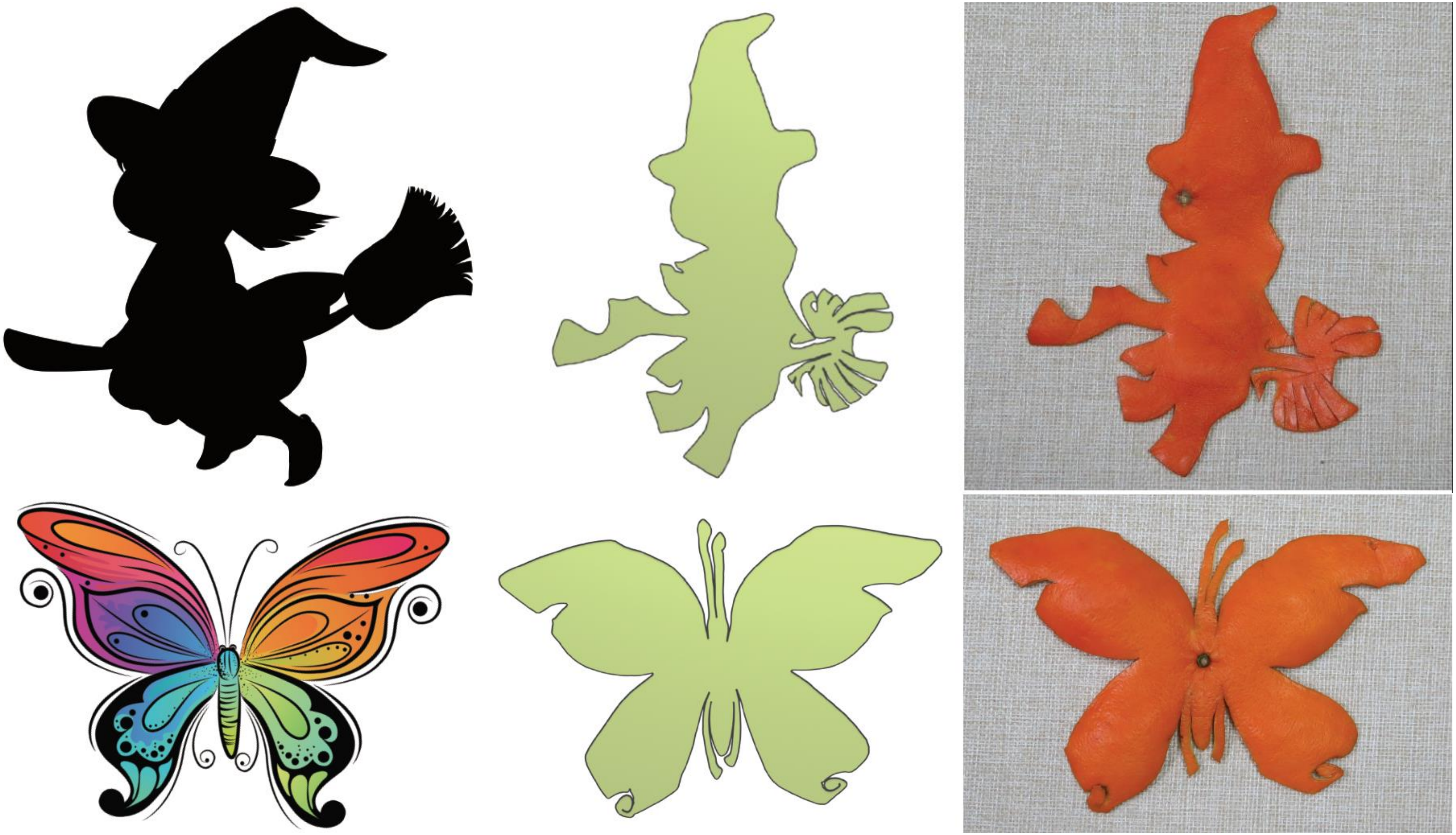

Designing shapes
20 × playback

Our results

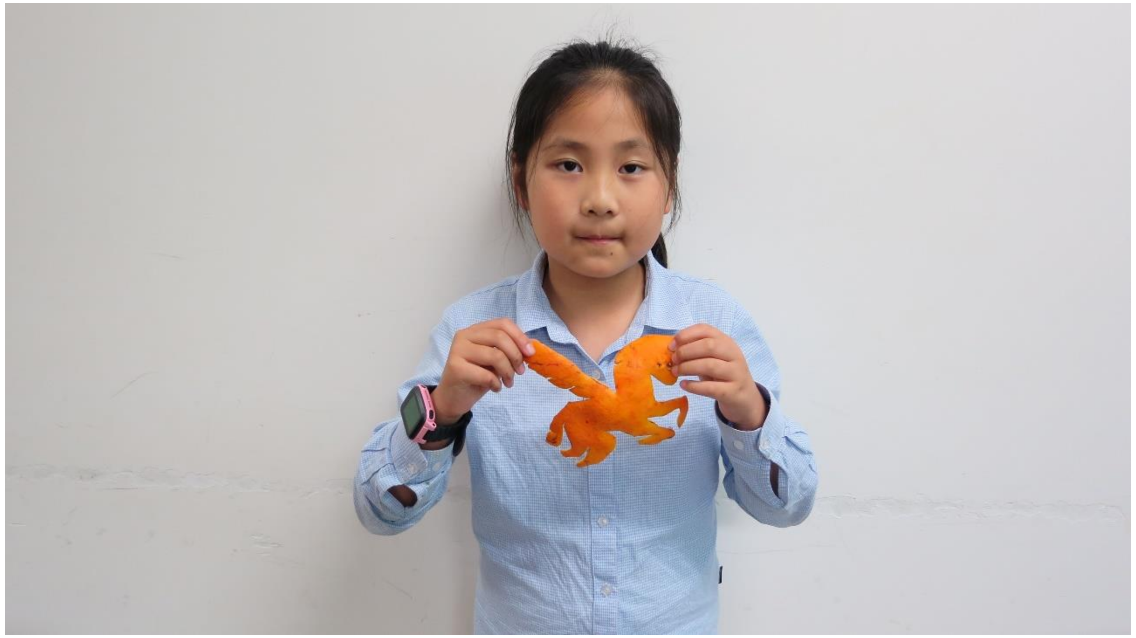



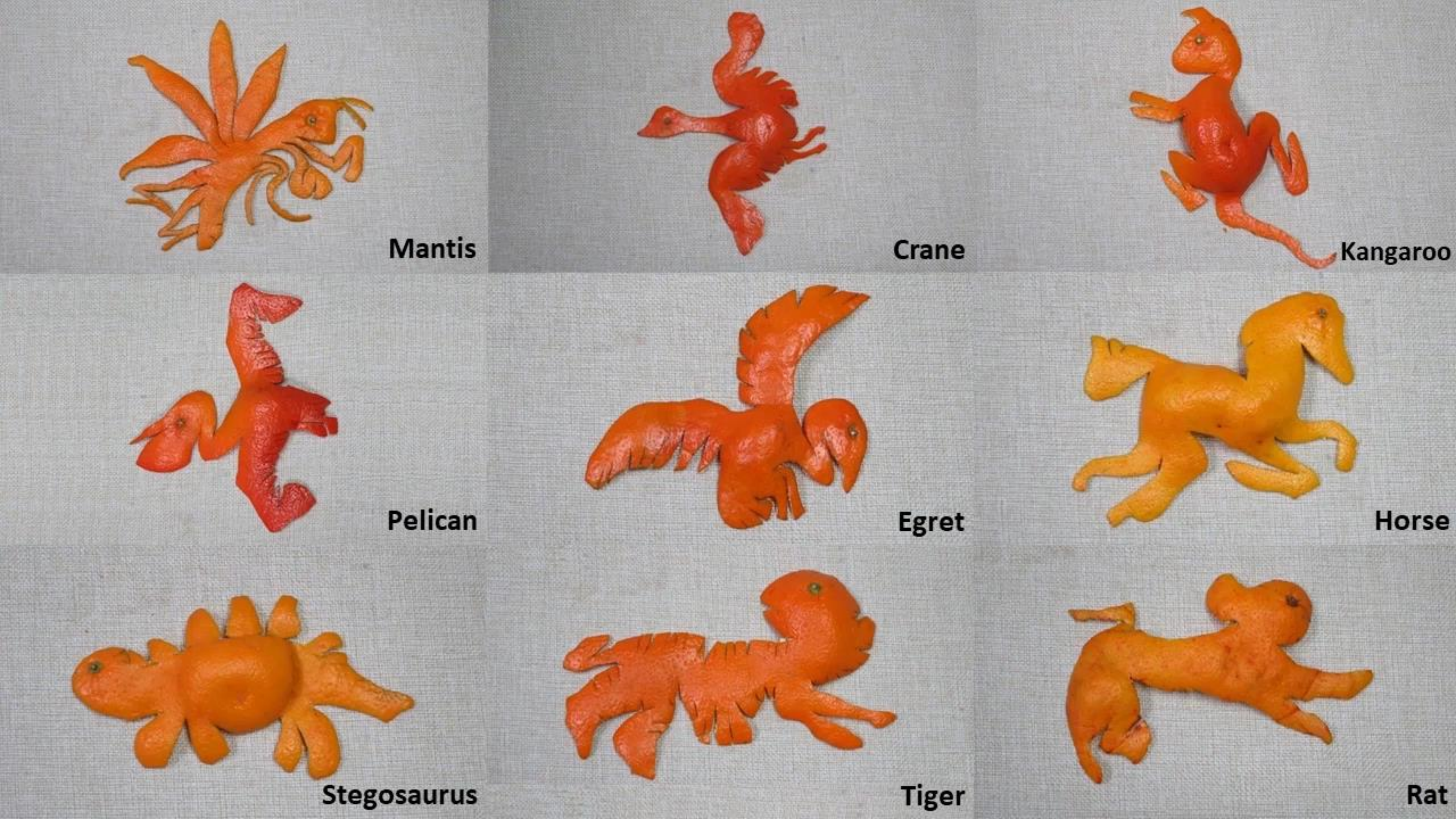






LOADING


Qoo
农夫山泉

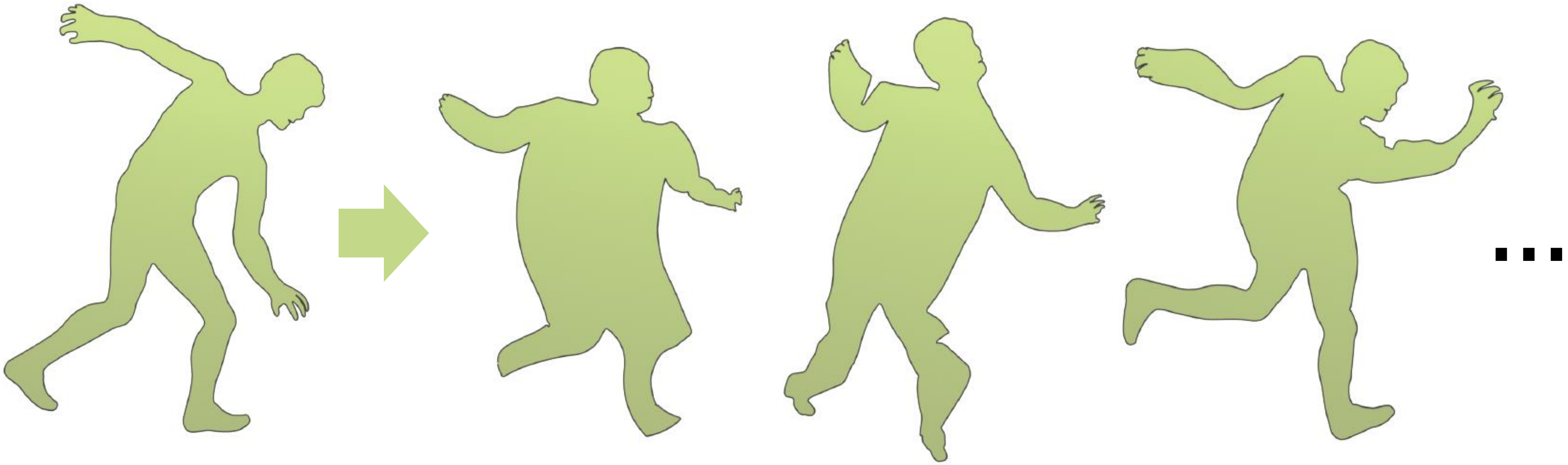



Mantis
Crane
Kangaroo
Pelican
Egret
Horse
Stegosaurus
Tiger
Rat

Conclusion

- A computational tool for peeling art design and construction.
- Unsuitable input 2D shapes are rectified by an iterative process.

Limitations: conservation principle



User input Interaction many times also cannot keep posture

Thank you