# Tele-Registration: A Field-Guided Registration for Feature-Conforming Shape Composition

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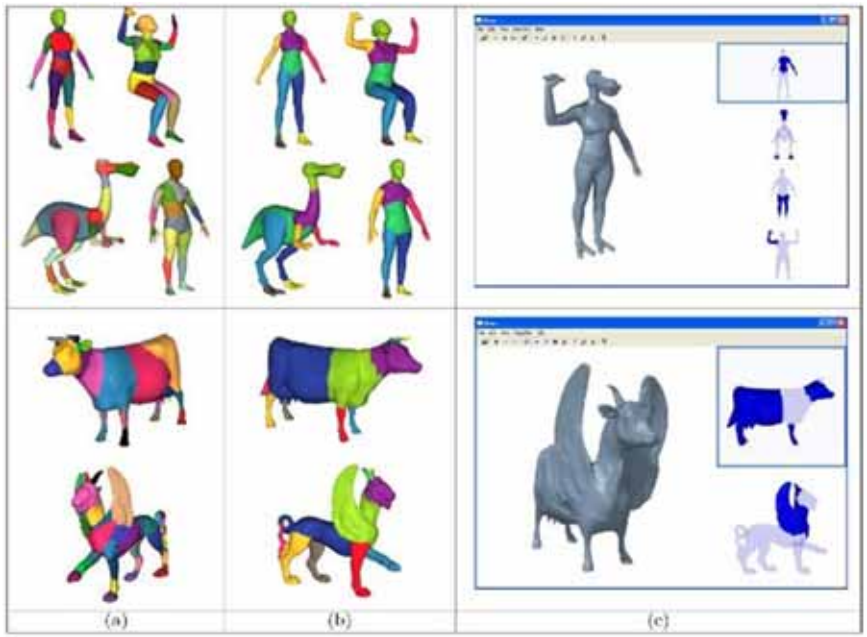
# Model creation by composition

[Funkhouser et al. 2004]

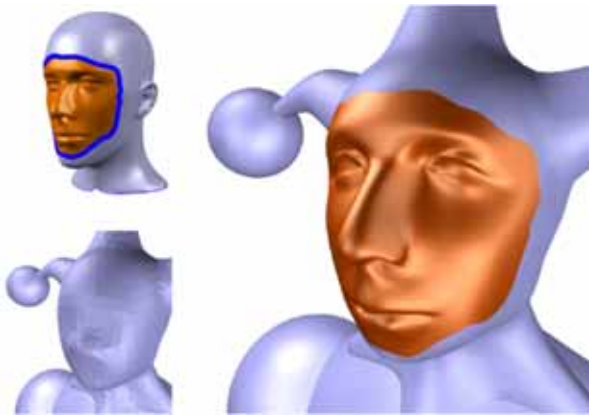



[Kreavoy et al. 2007]

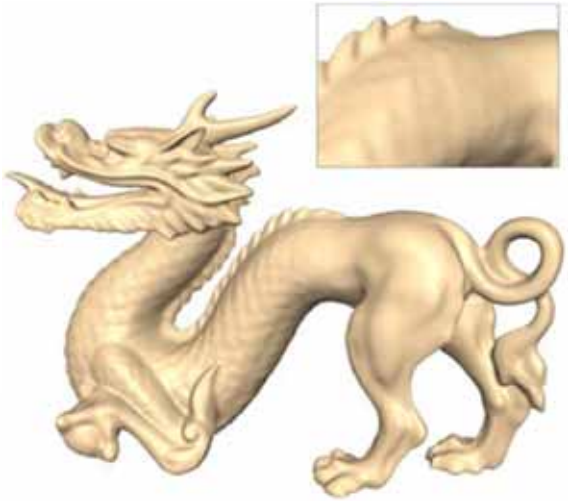
[Chaudhuri et al. 2011]

[Xu et al. 2012]

# Shape composition

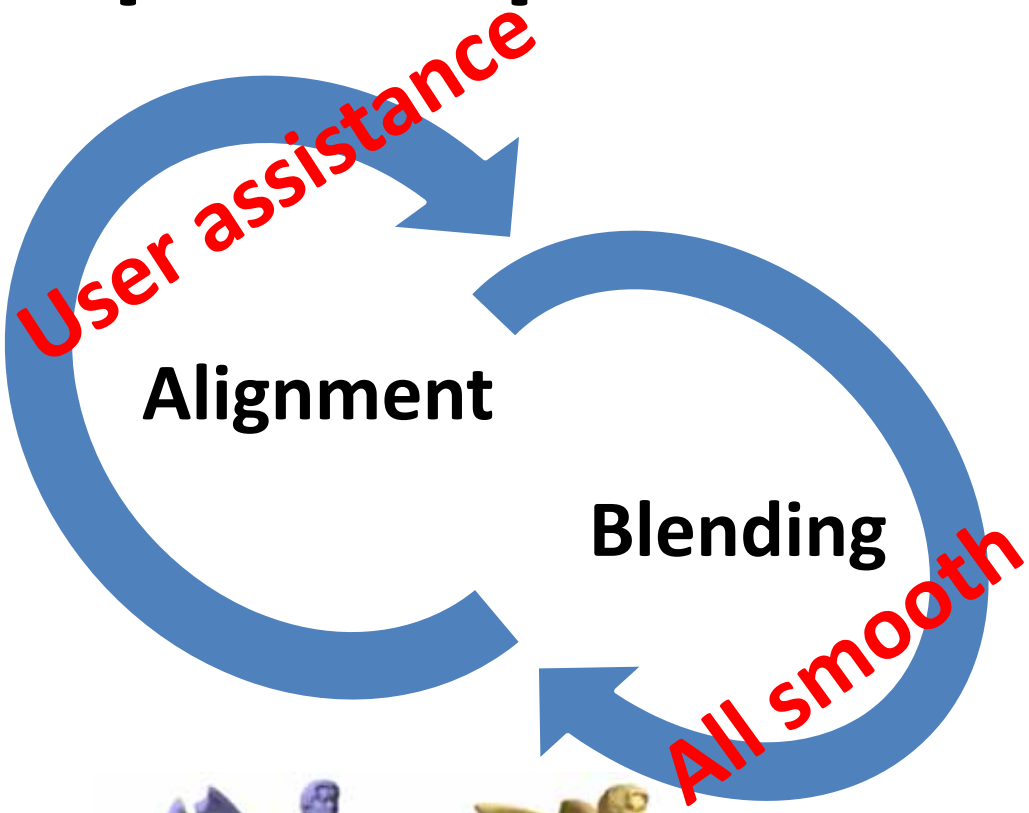


[Schmidt and Singh 2010]



[Sorkine et al. 2004]

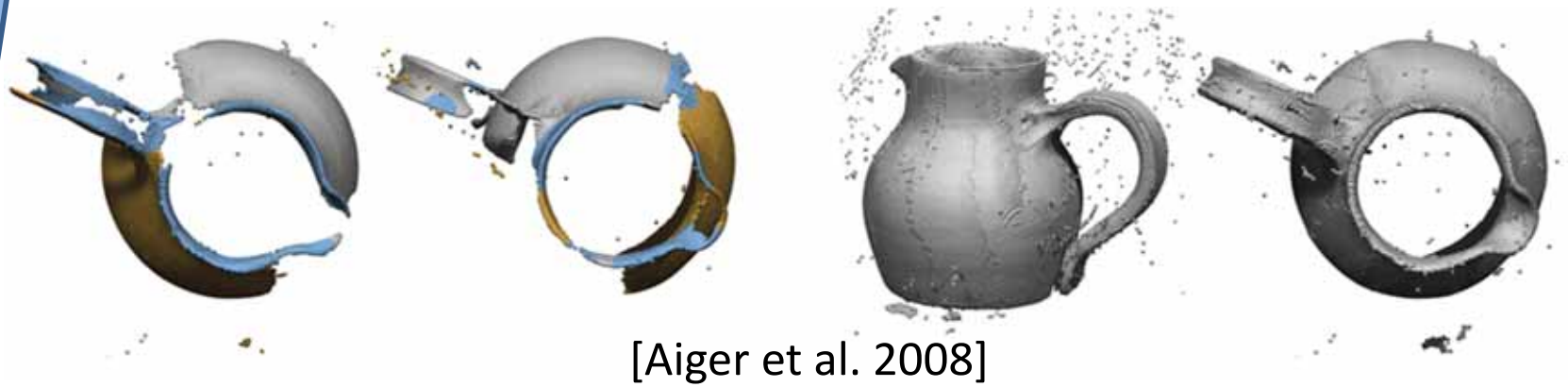
[Yu et al. 2004]



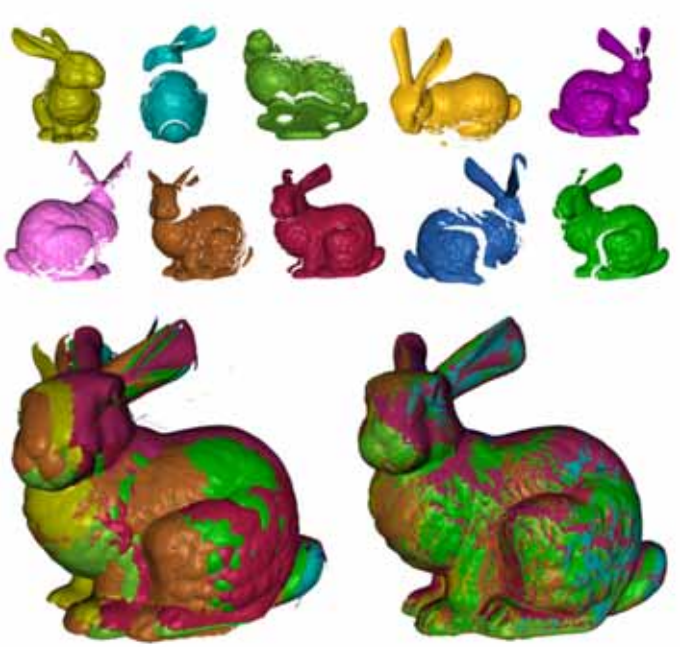

[Sharf et al. 2006]

Sufficient Overlap

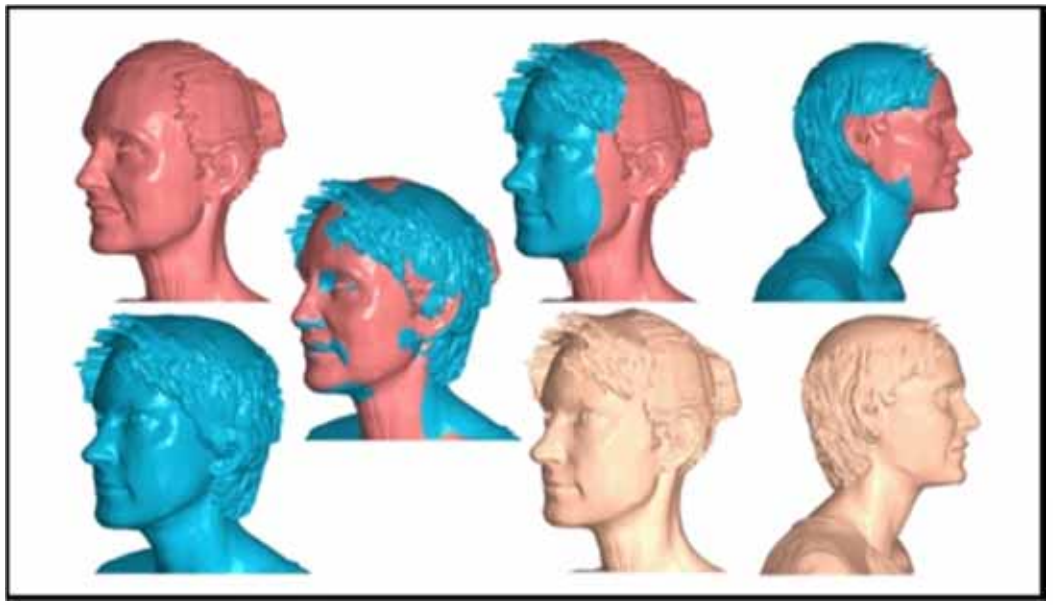
# Shape registration



[Aiger et al. 2008]

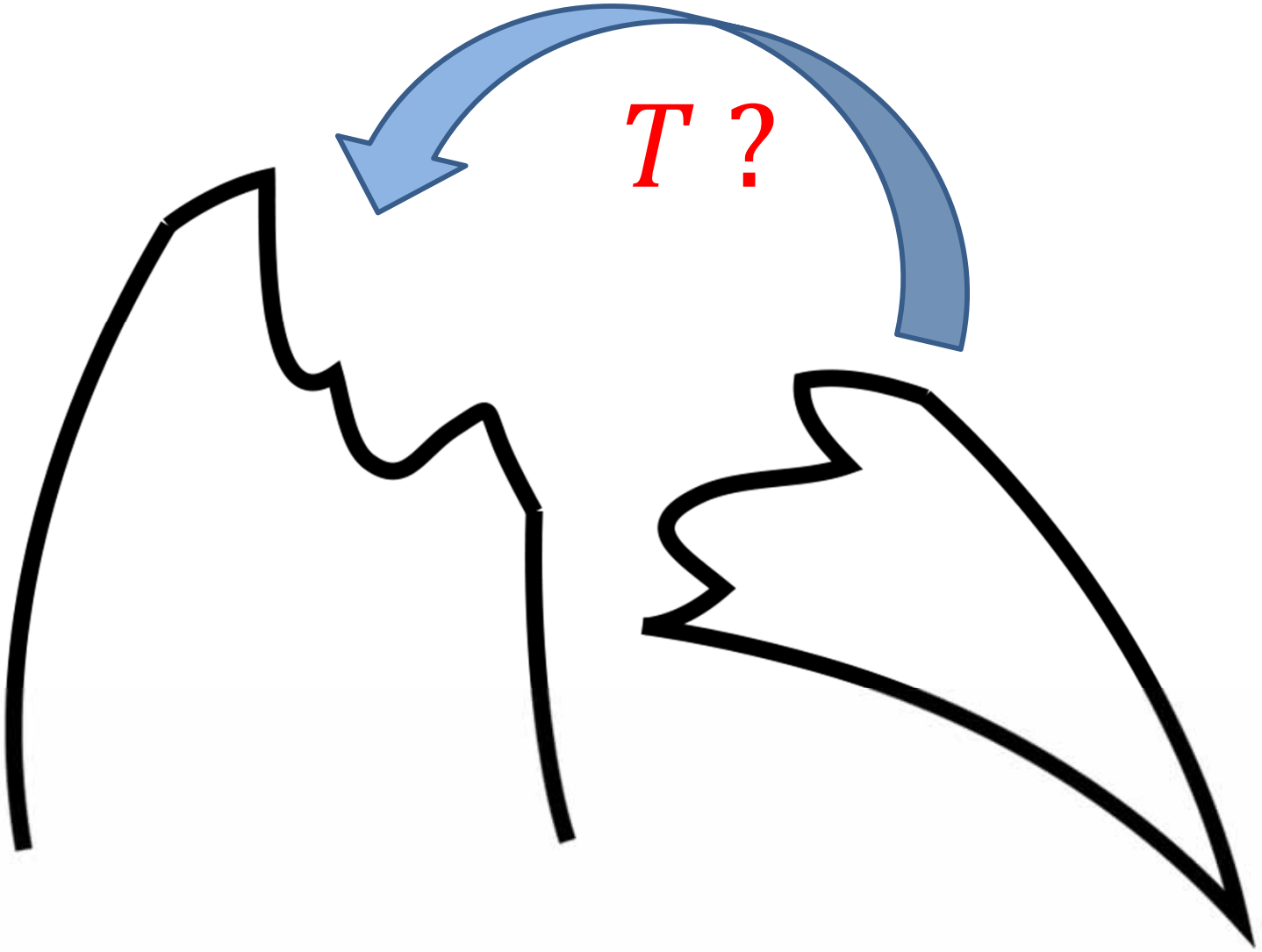


[Gelfand et al. 2005]

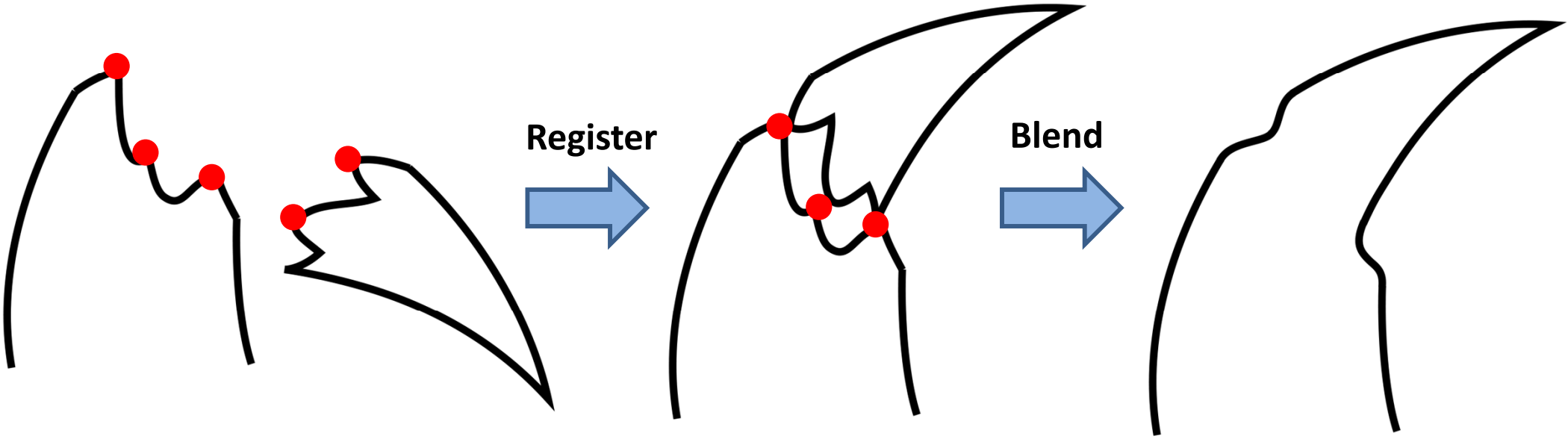


[Hassner et al. 2005]

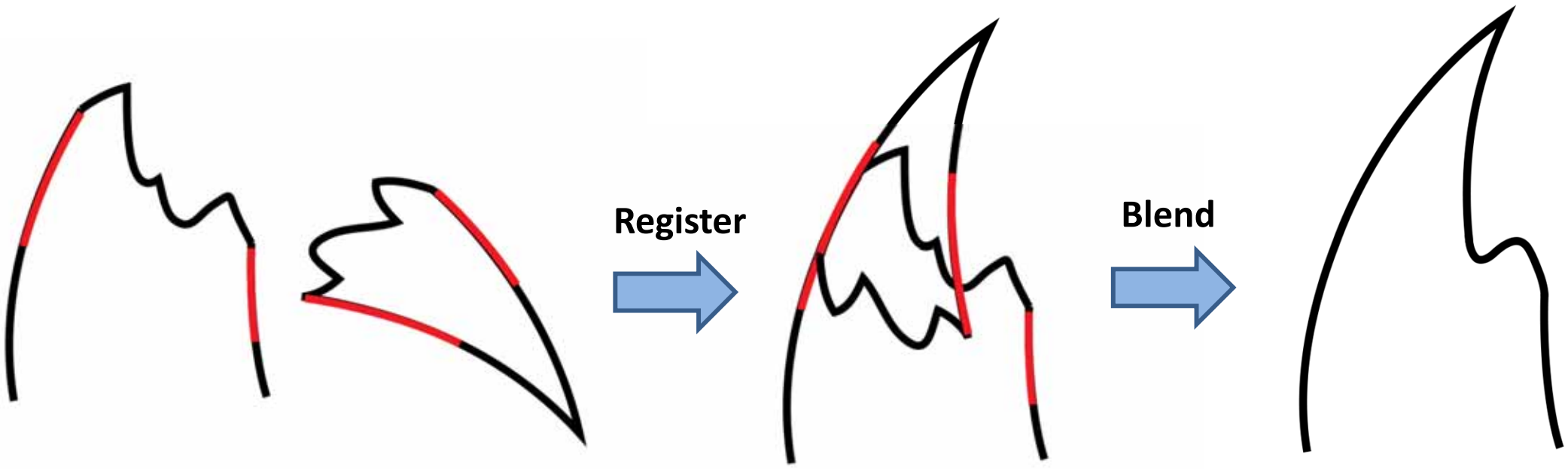
# Registration



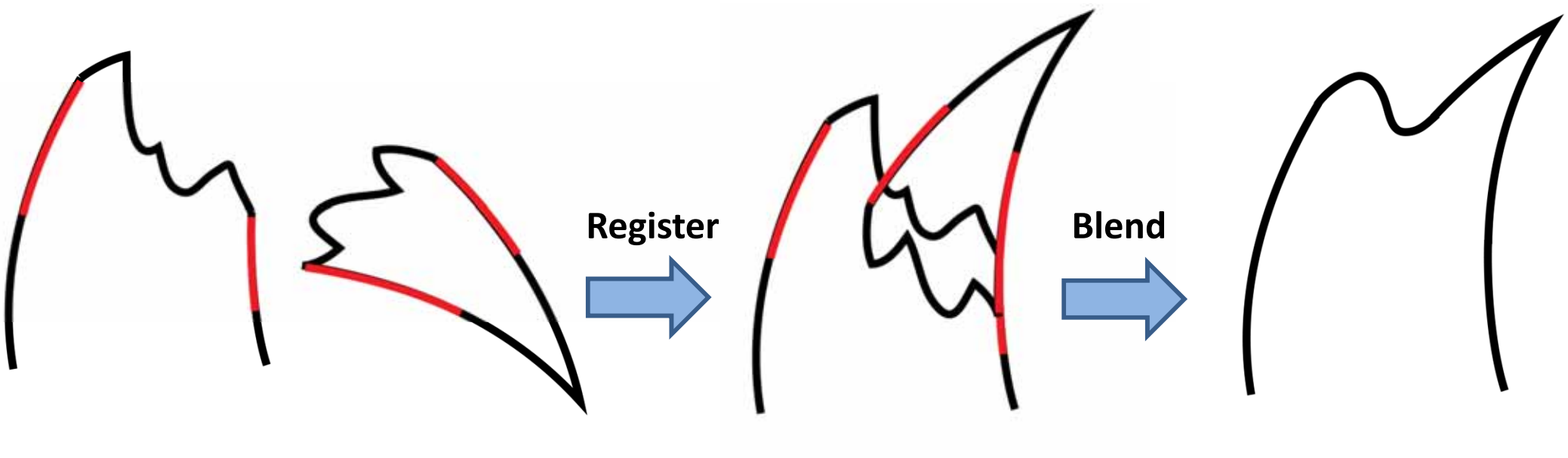
# Matching feature points?



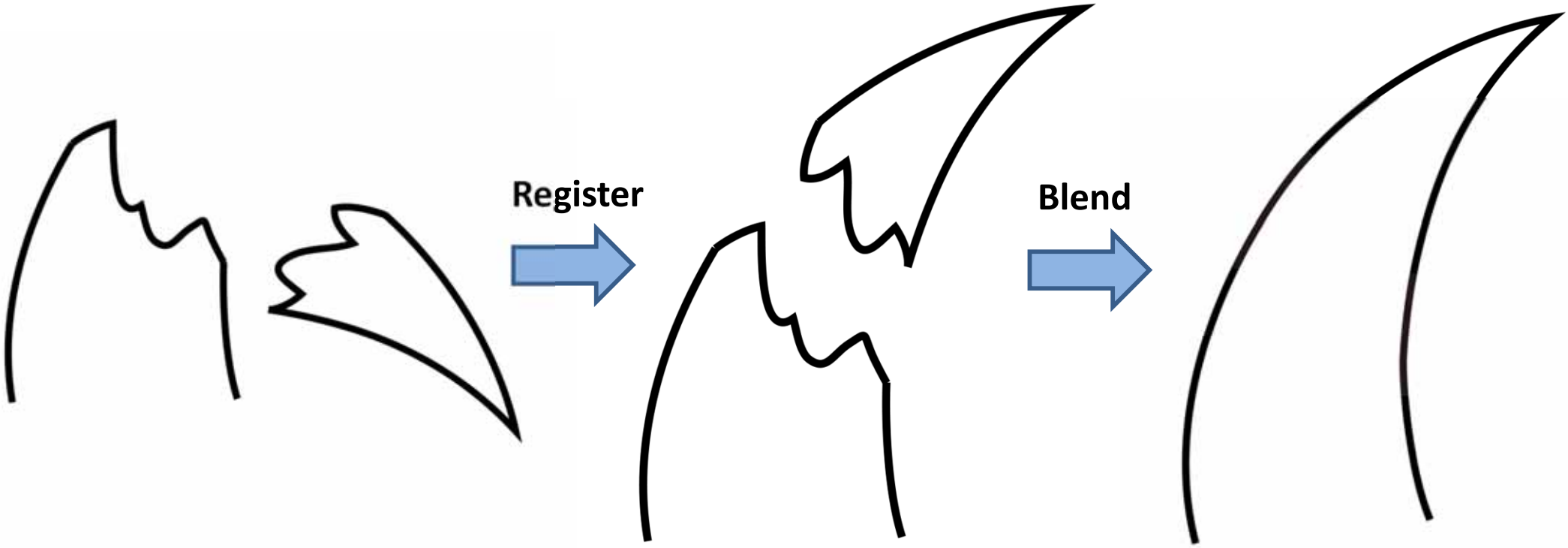
# Matching salient curves?



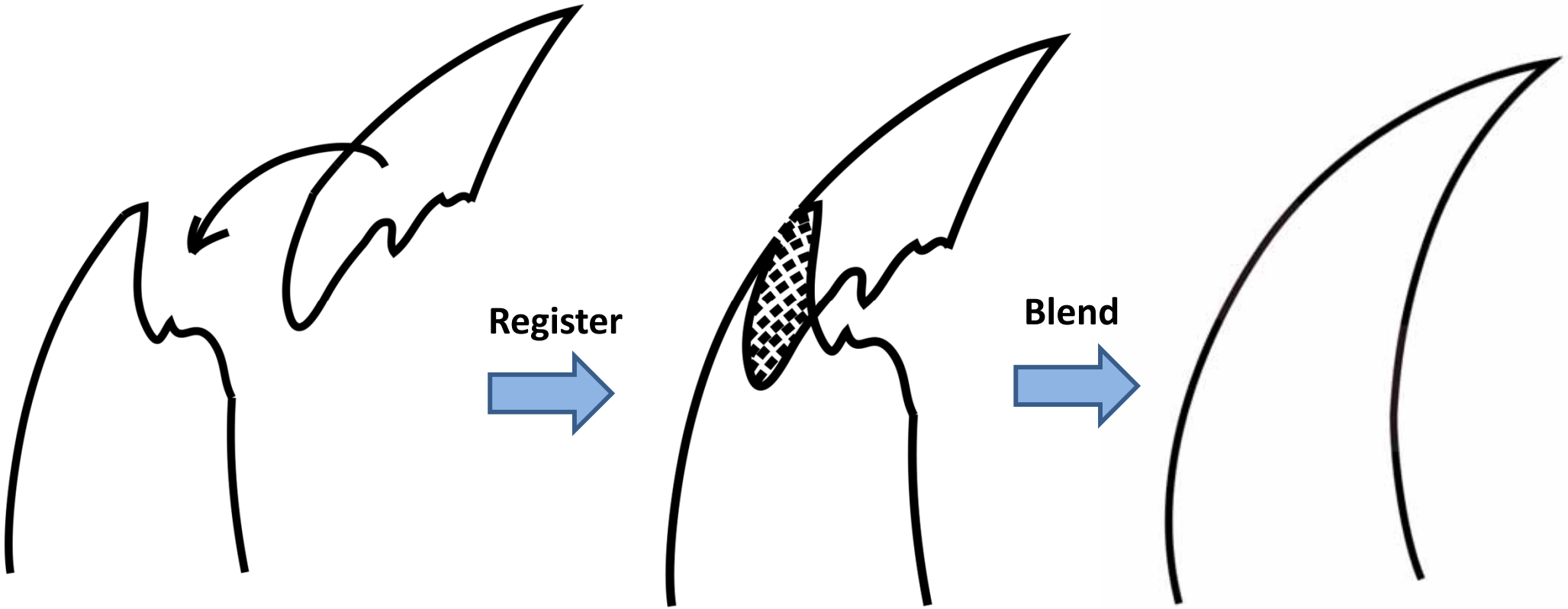
# Matching salient curves?



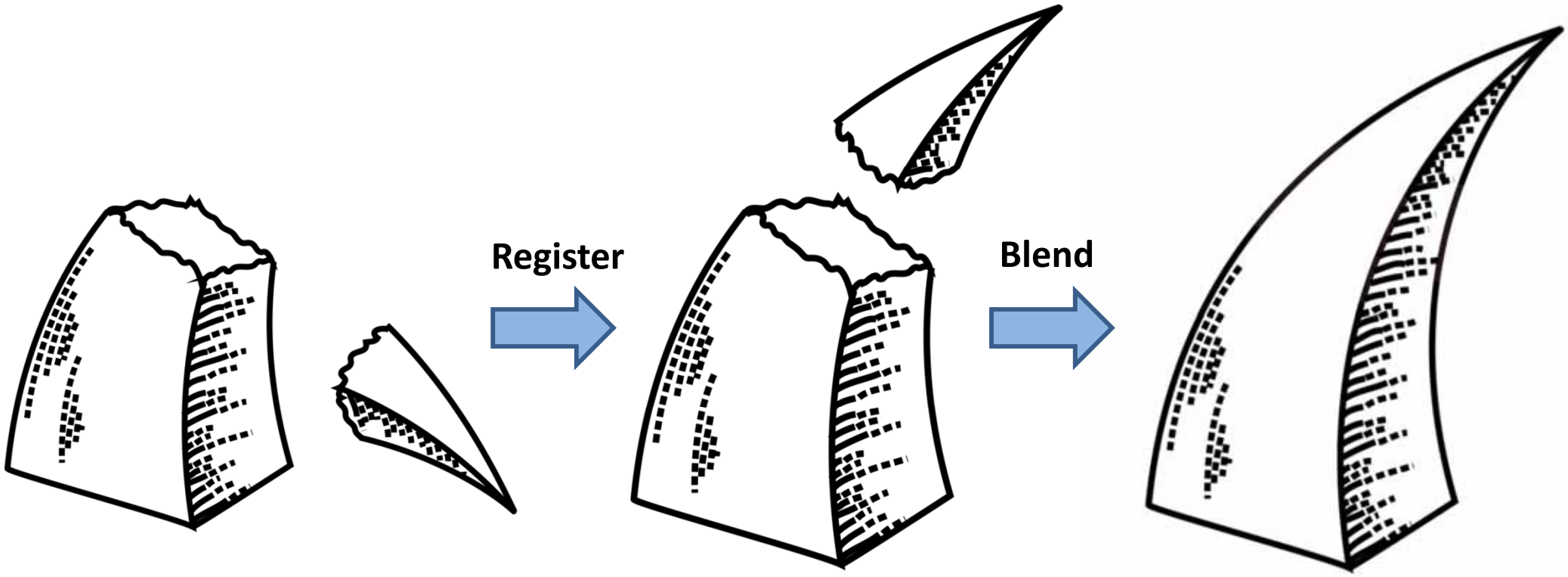
# No overlap!!!!!



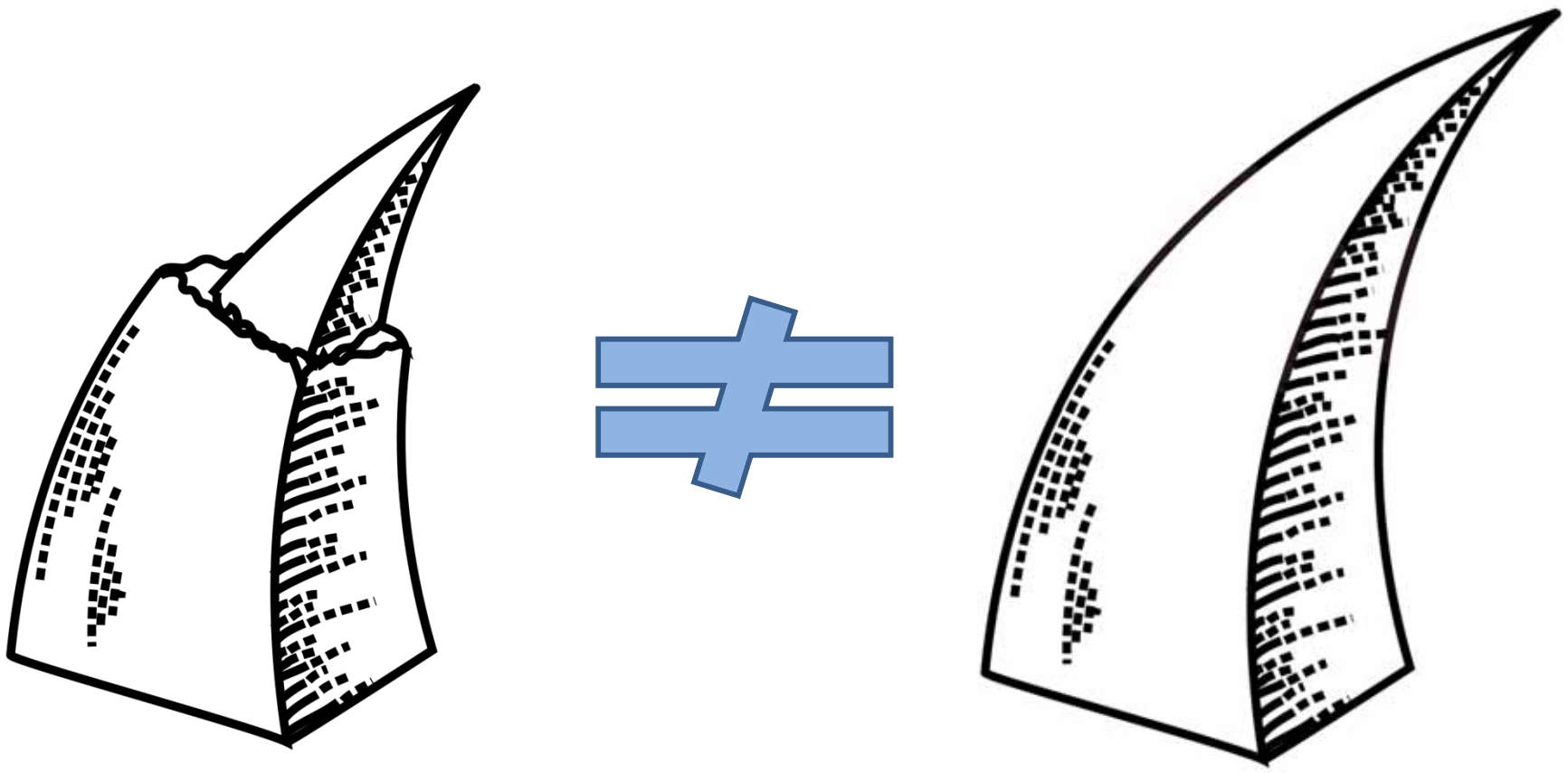
# Possibly with some overlap



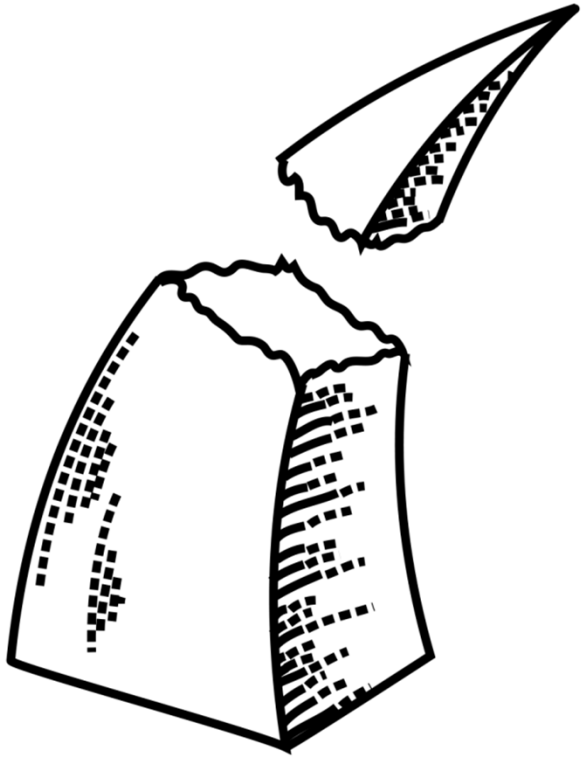
# No overlap in 3D!!!!



# If enforce a contact or overlap?

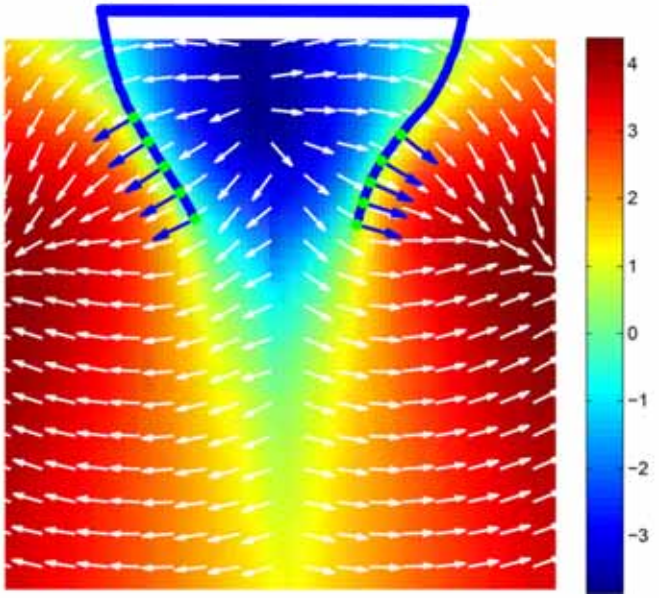


# Tele-registration

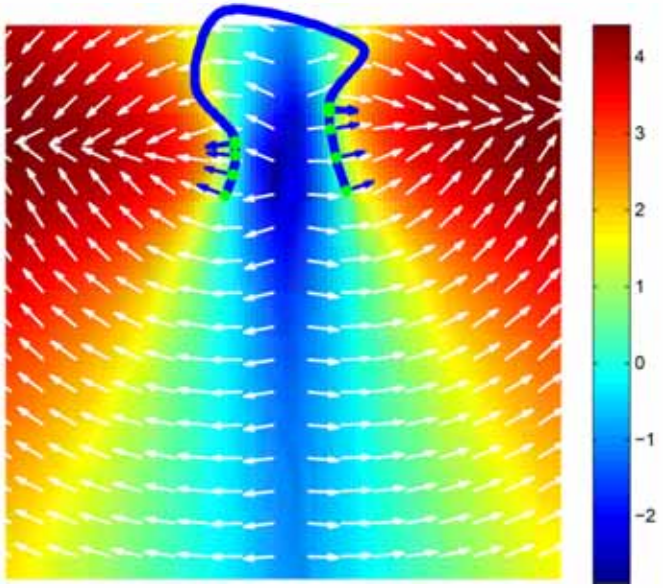


# Tele-registration

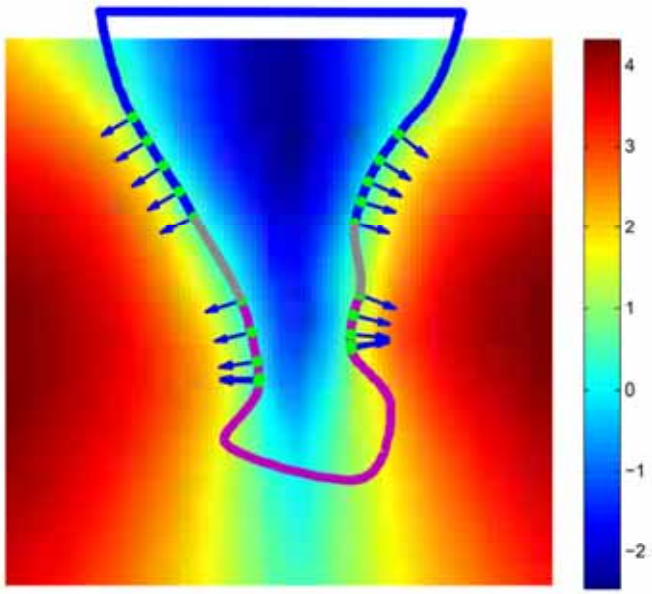
# How?




$P$ & $F_P$



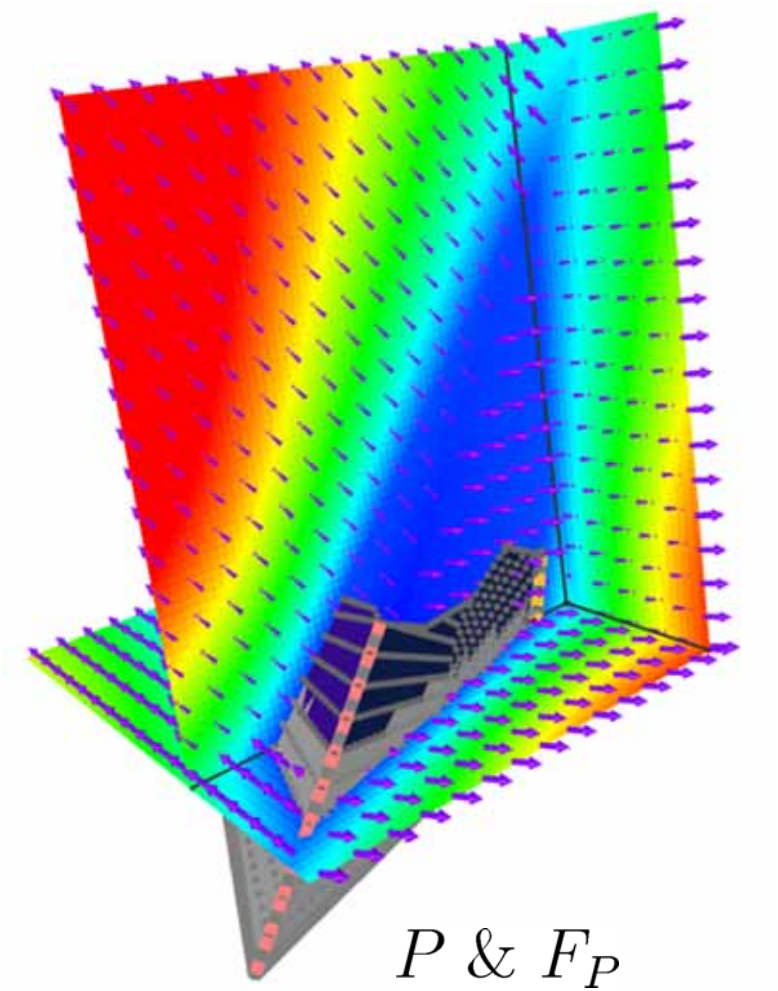

$Q$ & $F_Q$



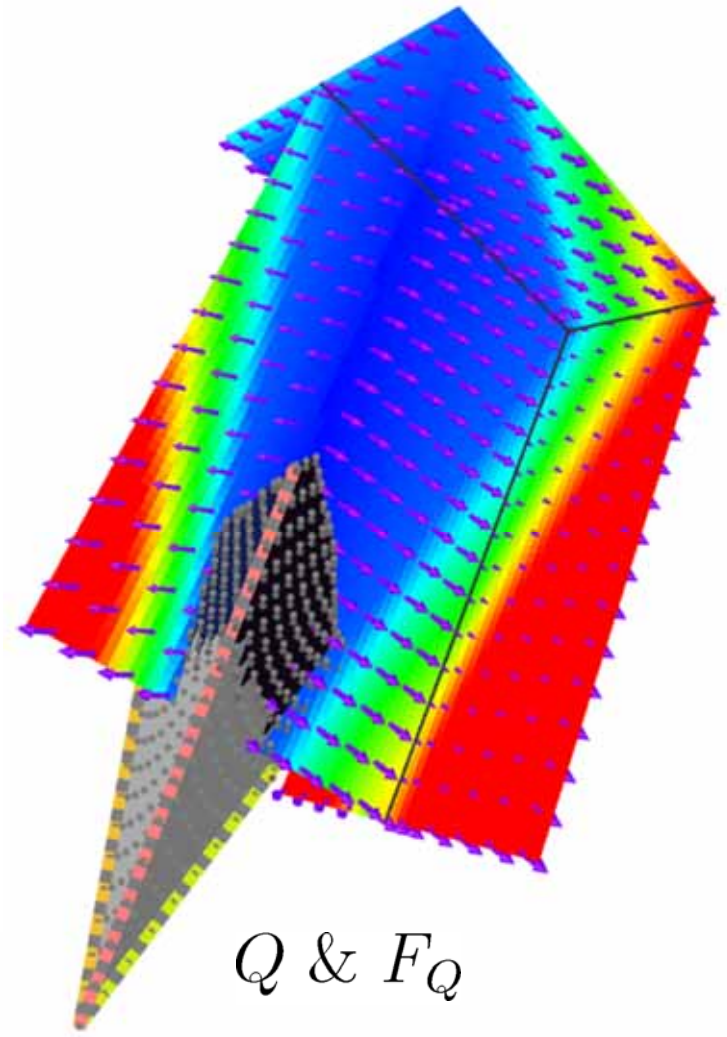

Tele-registration

**Registering a part in the ambient field of the other!**

**3D ambient field** that expresses the surface continuation into the volume.

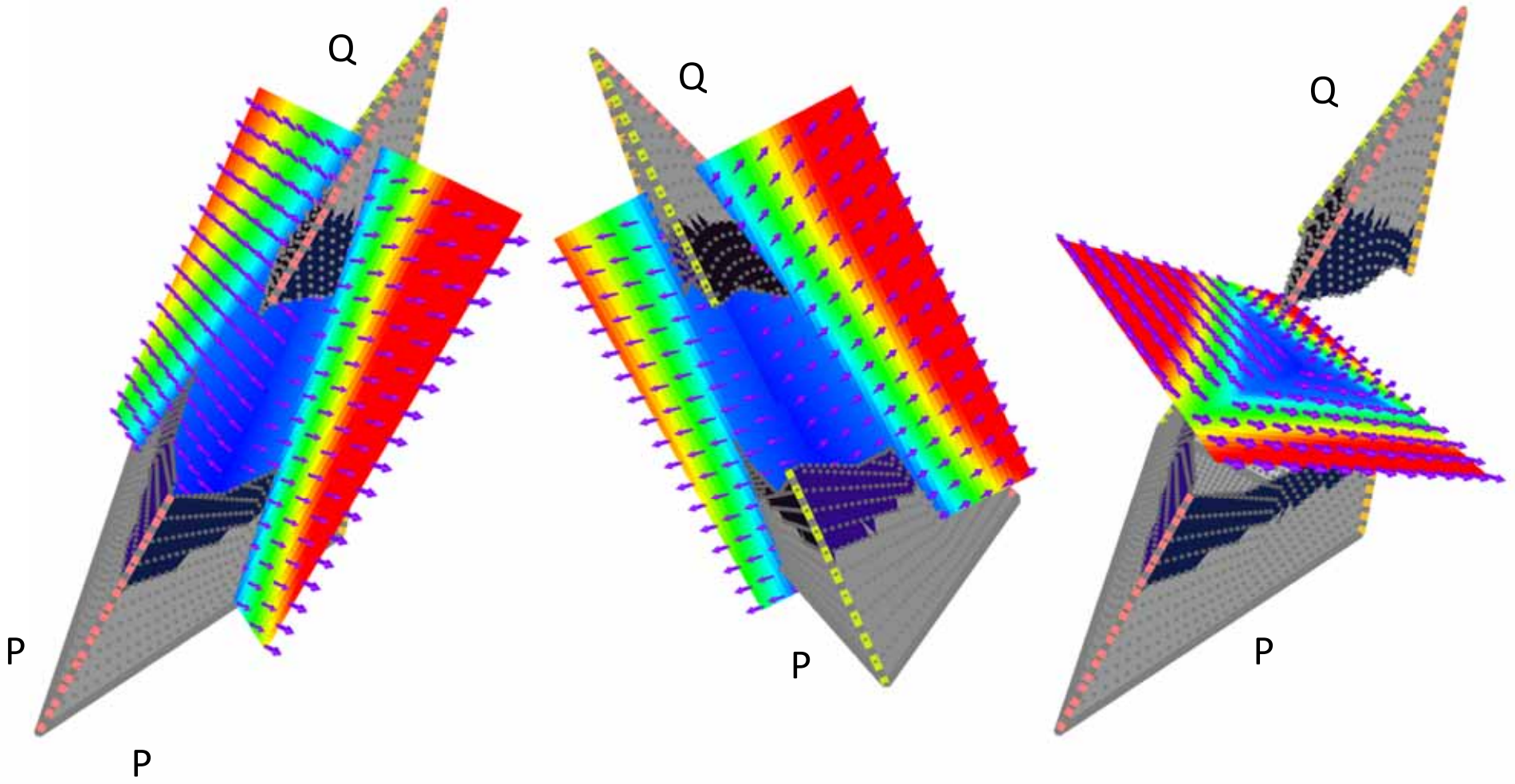


$P$ & $F_P$



$Q$ & $F_Q$

# Tele-registration in 3D



# Field-guided rigid alignment

How well part $Q$, under given transformation $T$, fits the **ambient field** of $P$ can be computed using the average likelihood of Q 's vertices:

$$\frac{1}{N_Q} \sum_{v \in \Omega_Q} K_P(T \cdot v)$$

The goal of registration is to find a rigid transformation that maximizes the total likelihood of the two parts in each other's fields, i.e., **surface-to-field registration:**

$$T = \arg\max_T E(T),$$

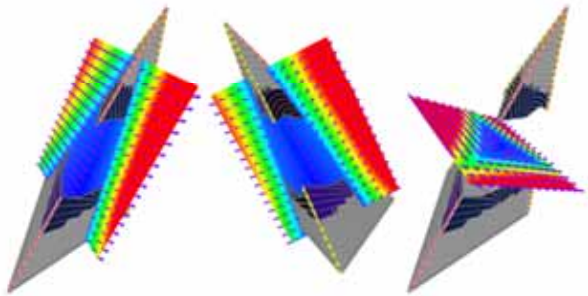
$$E(T) = \frac{1}{N_Q} \sum_{v \in \Omega_Q} K_P(T \cdot v) + \frac{1}{N_P} \sum_{u \in \Omega_P} K_Q(T^{-1} \cdot u).$$

# Orientation-dependent Likelihood

$K_P(v)$ expresses the likelihood that the vertex $v \in \Omega_Q$ with its normal $\mathbf{n}_v$ lied on the **surface extension** of $P$.

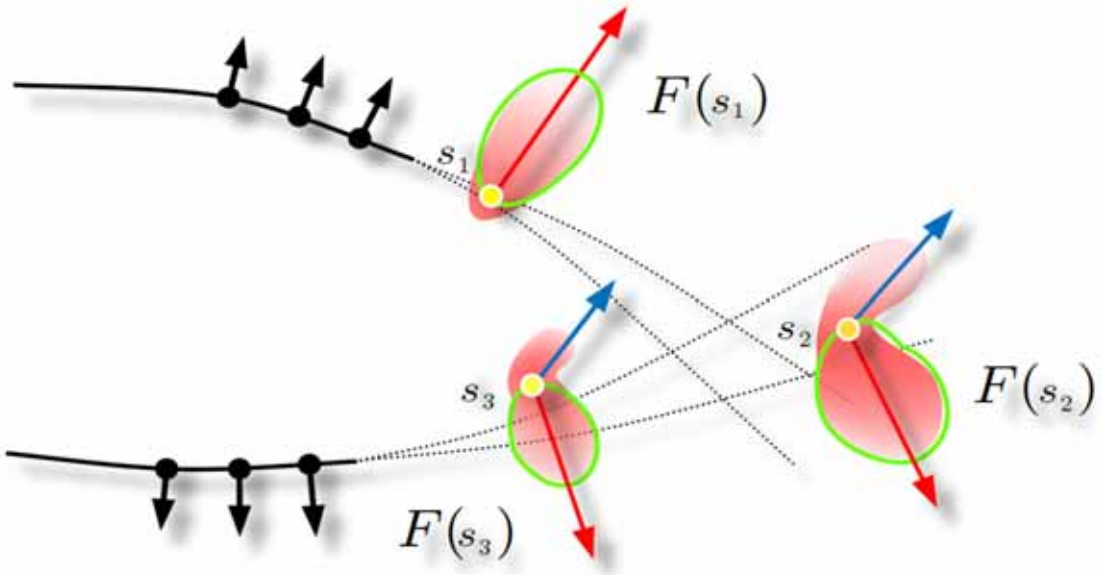
This can be evaluated by a combination of two terms: one that measures the agreement with **orientation**, and the other with the **location**.

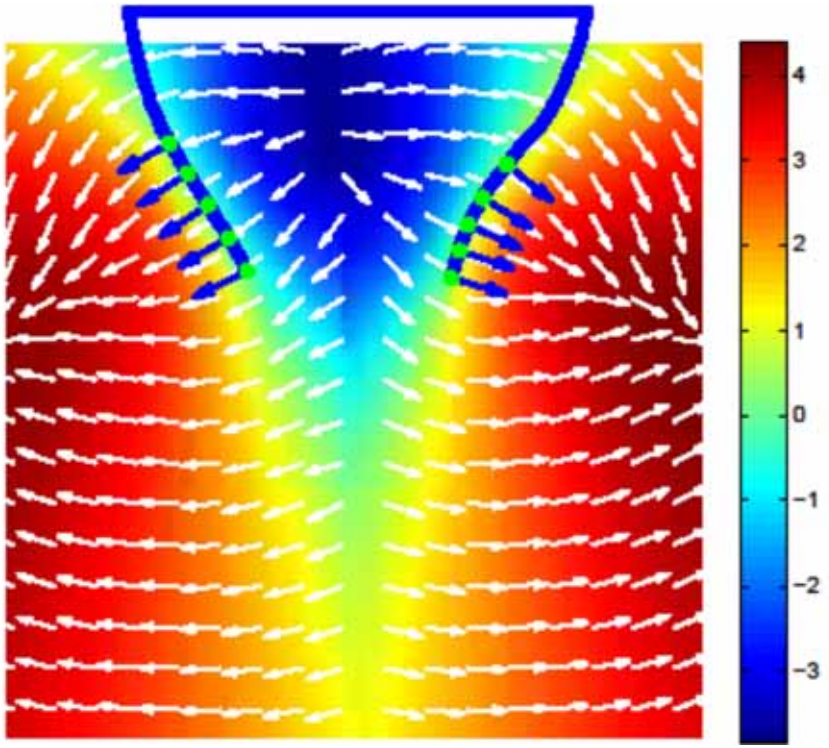
$$K_P(v) = \underbrace{(\max(\mathbf{n}_v^\top \mathbf{d}_P(v), 0))^w}_{\text{Orientation}} \underbrace{e^{-|l_P(v)|}}_{\text{Location}}.$$



# Ambient field

There are two fields: a scalar field (the color in the right figure) and  a vector field (the white arrows in the right figure) , which express the surface continuation into the volume.



# Field Generation

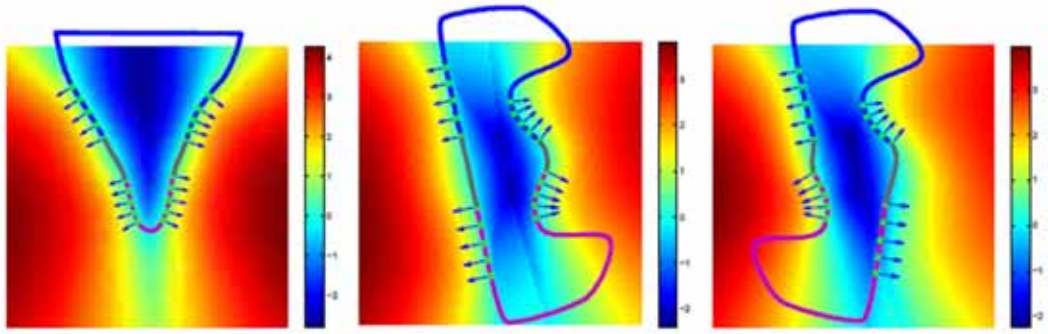
We first solve for the directions $\mathbf{d}_P(s)$ and then compute the scalar field with sign distances $l_P(s)$ (details in the paper).

$$\mathbf{d}_P(s) = \max_{\mathbf{d}} \frac{\sum_{u \in \Omega_P} \phi_1(s,u)\phi_2(\mathbf{d},u)}{\sum_{u \in \Omega_P} \phi_1(s,u)},$$

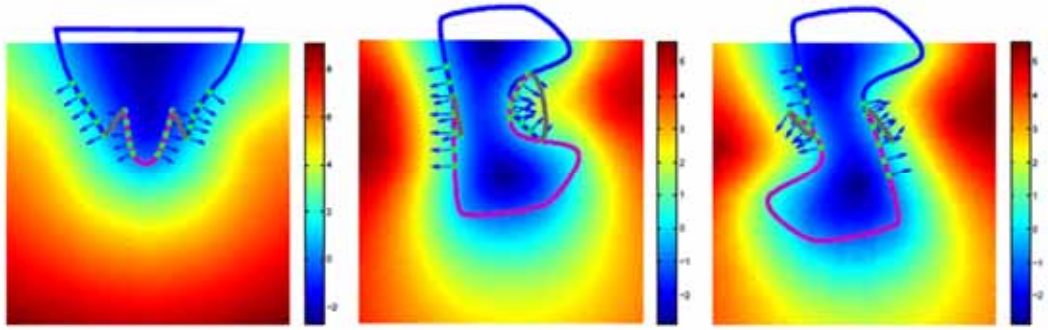
$$l_P(s) = \frac{\sum_{u \in \Omega_P} \phi_2(\mathbf{d}_P(s),u)\phi_3(s,u)}{\sum_{u \in \Omega_P} \phi_2(\mathbf{d}_P(s),u)}.$$

# Why a new ambient field?

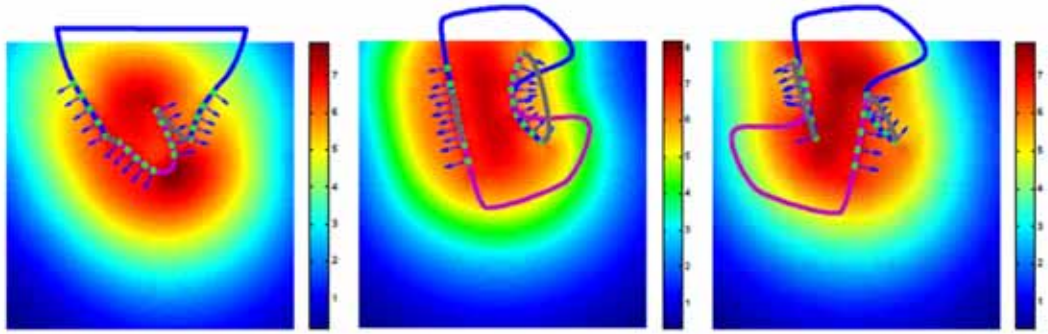
**Our field:**



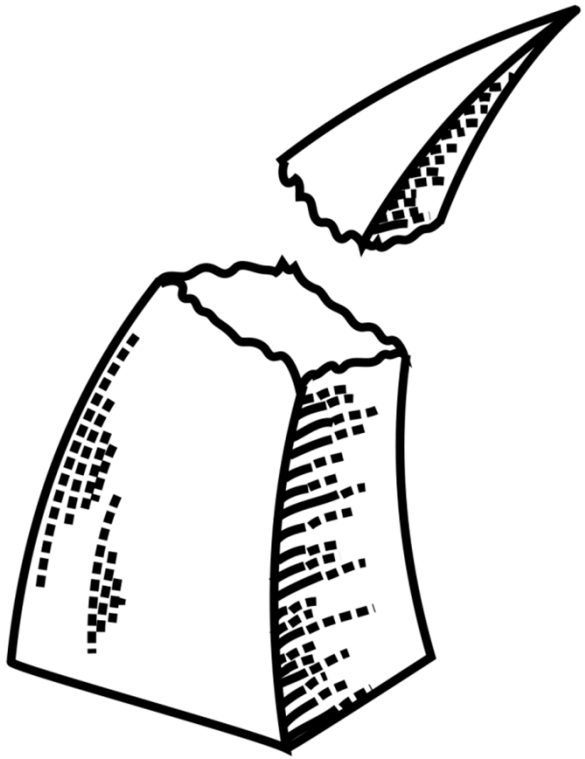
**RBF field:**



**Tensor Voting field:**

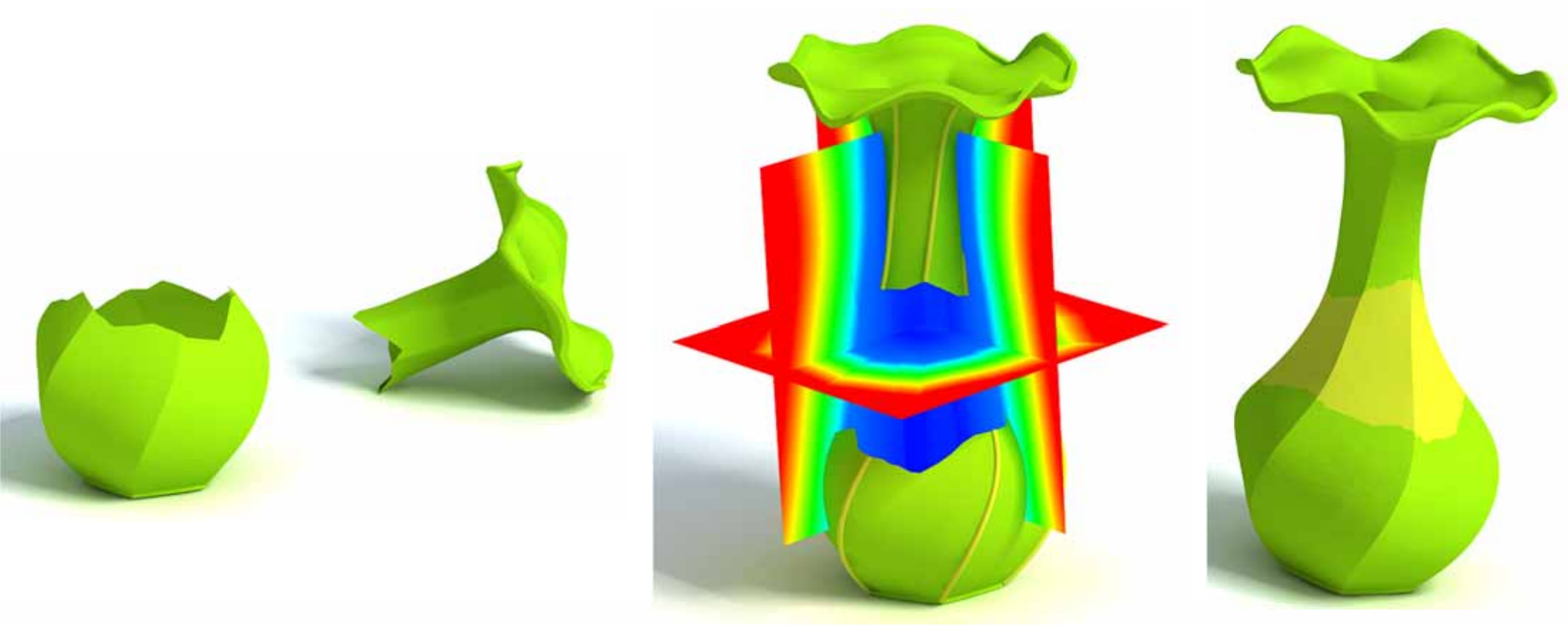


# Tele-registration

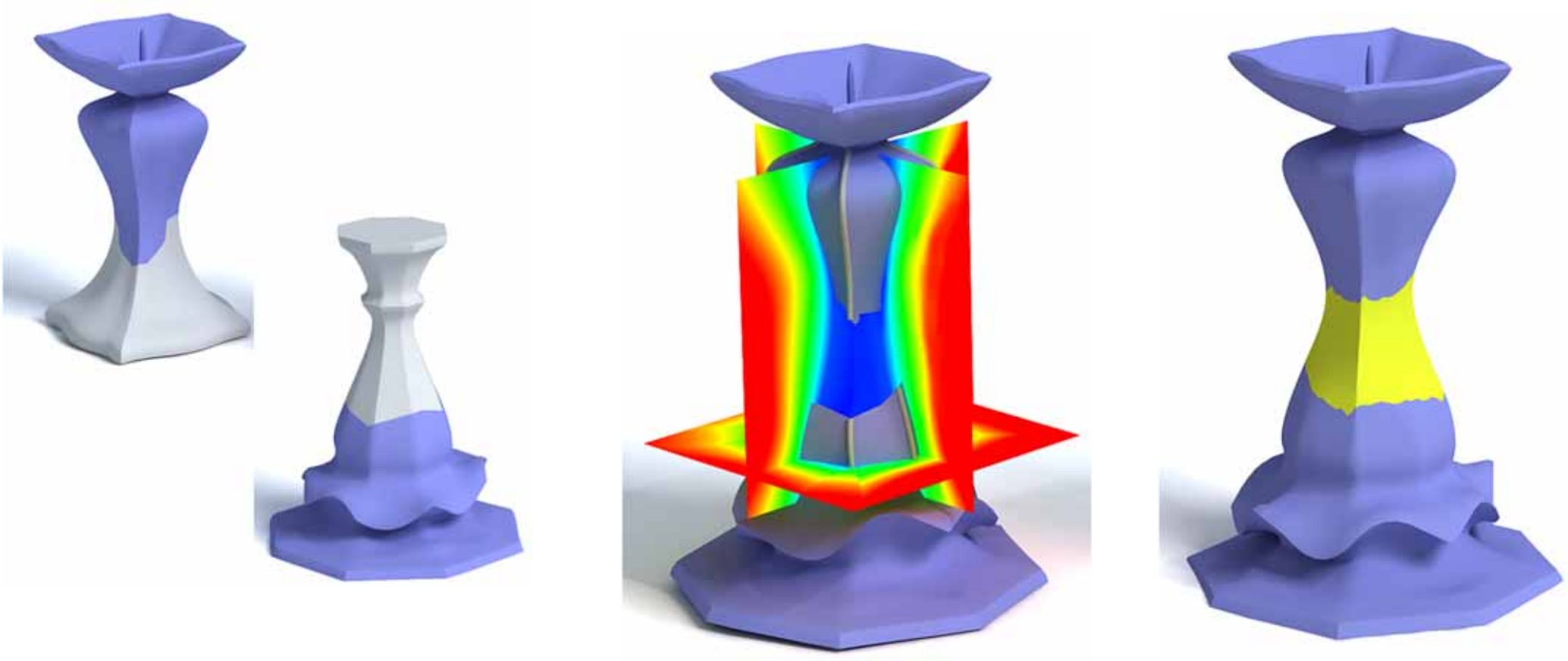


**Parts with sharp features**

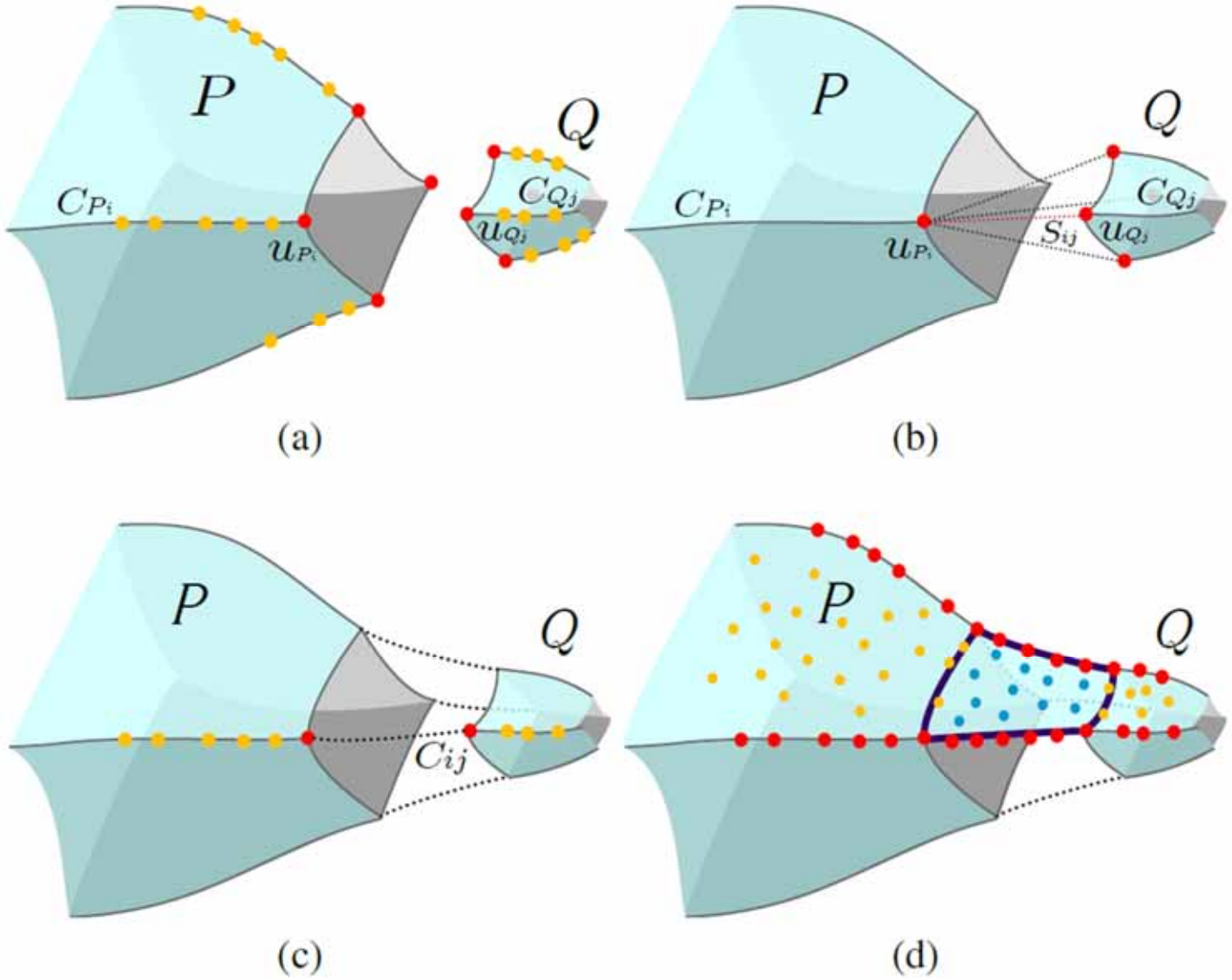
# Preserve sharp features



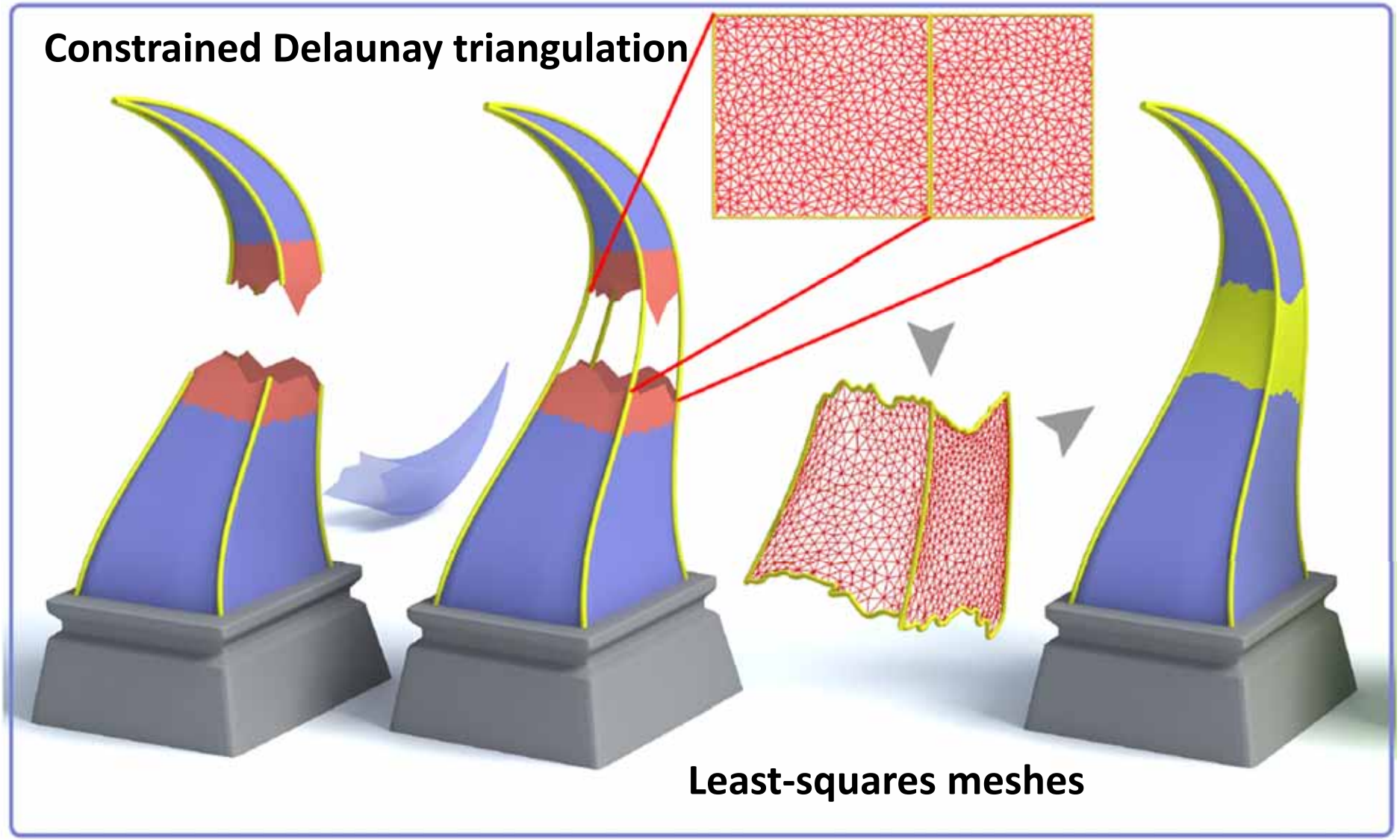
# Deal with mismatched features



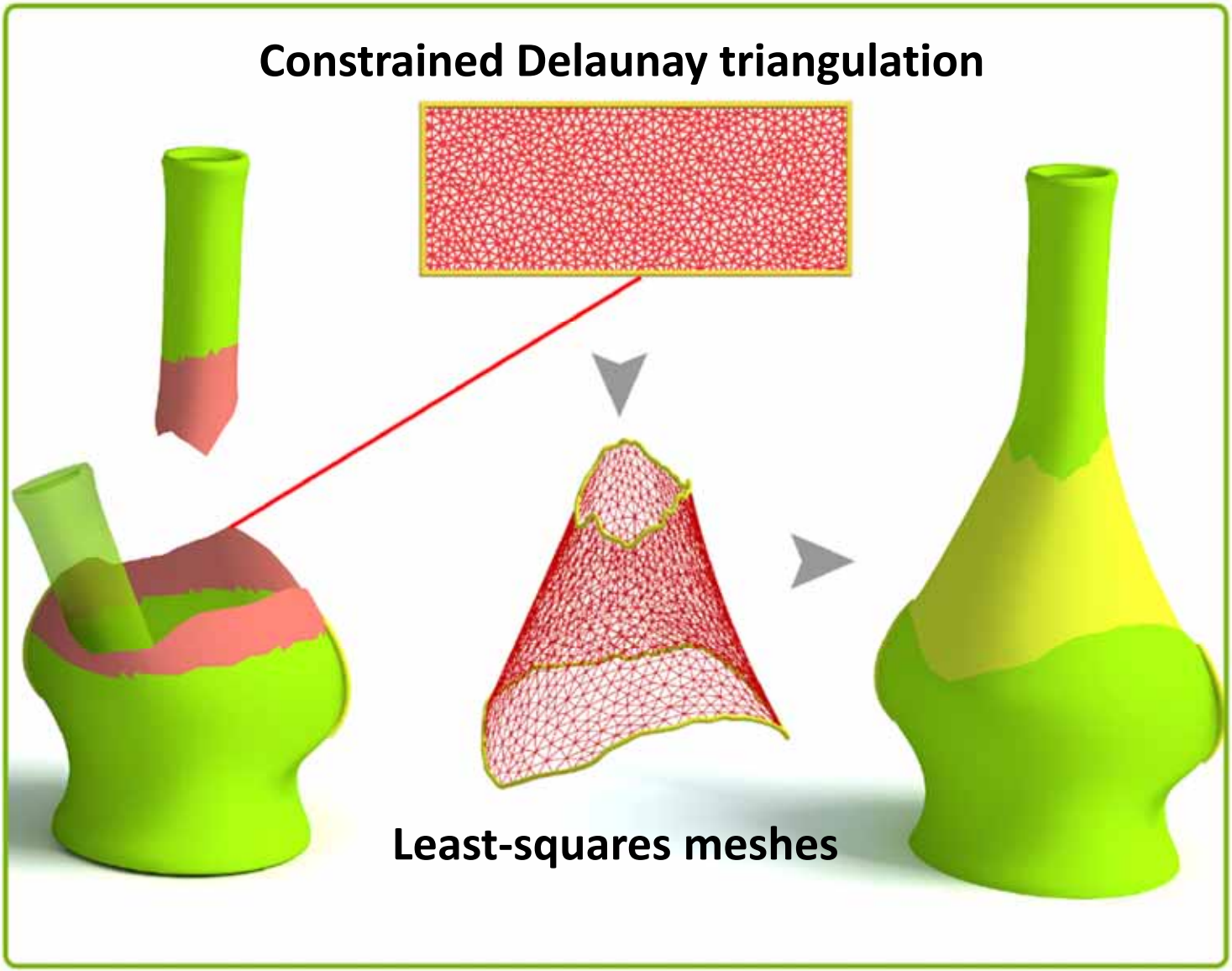
# Salient curve interpolation



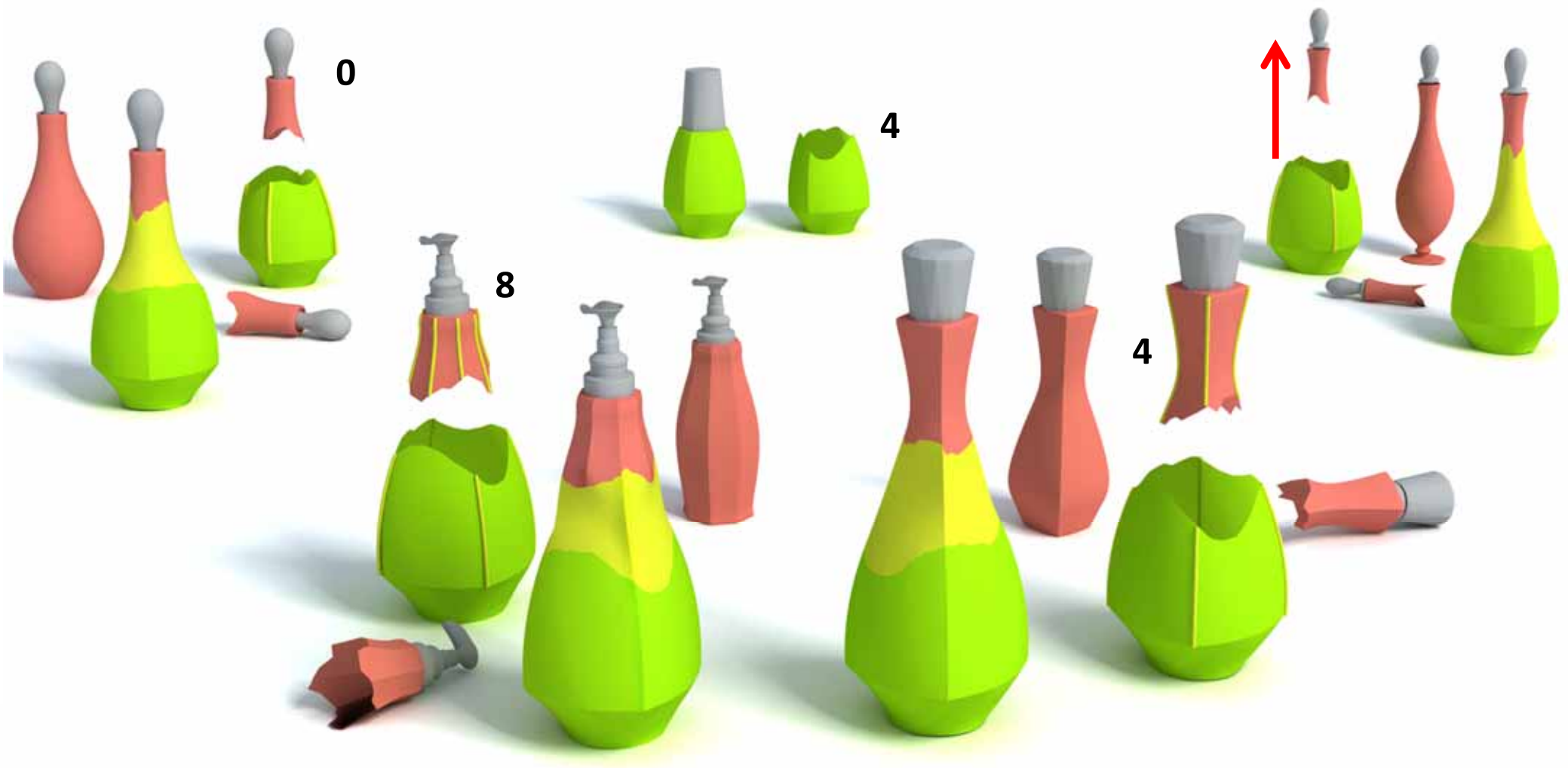
# Piecewise smooth gap-filling



# Blending

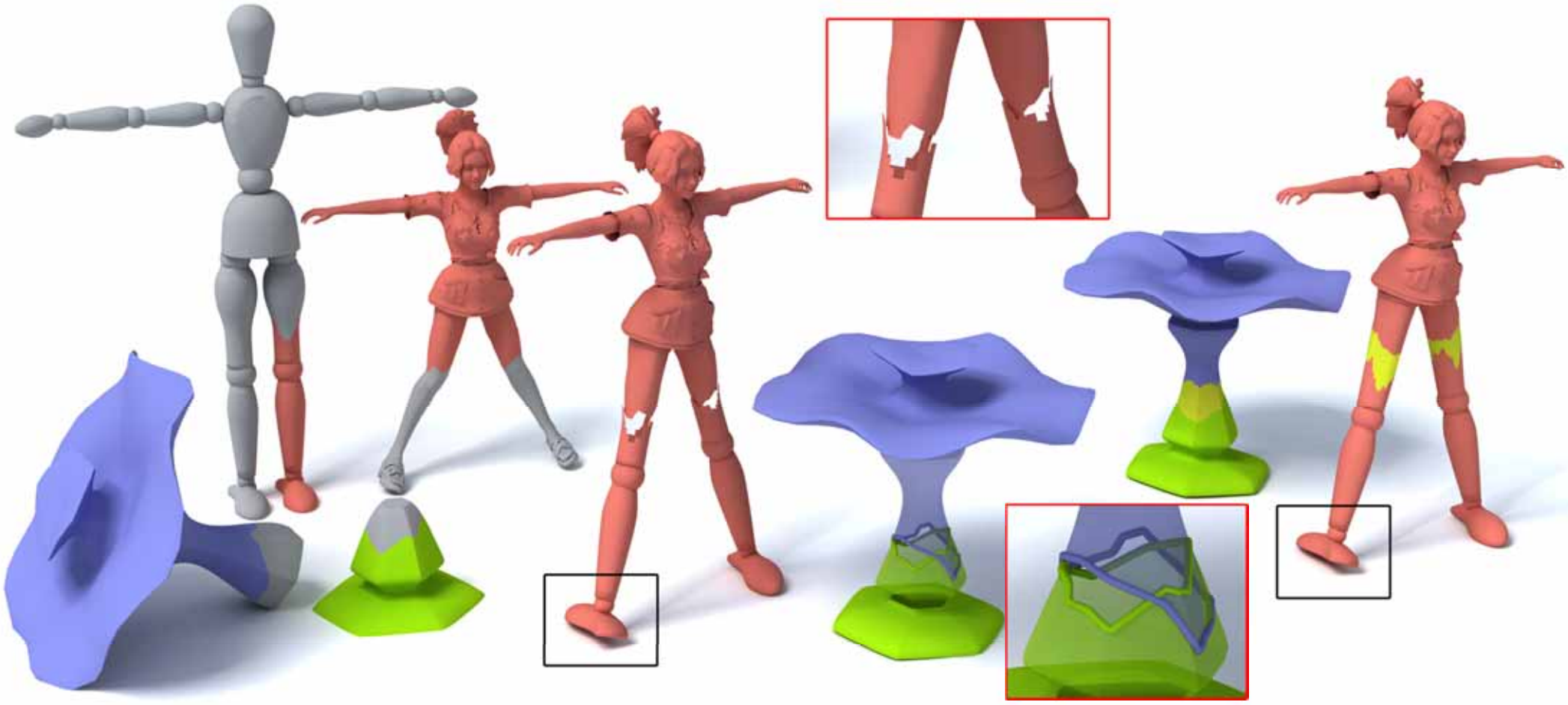

Constrained Delaunay triangulation
Least-squares meshes

# Some results

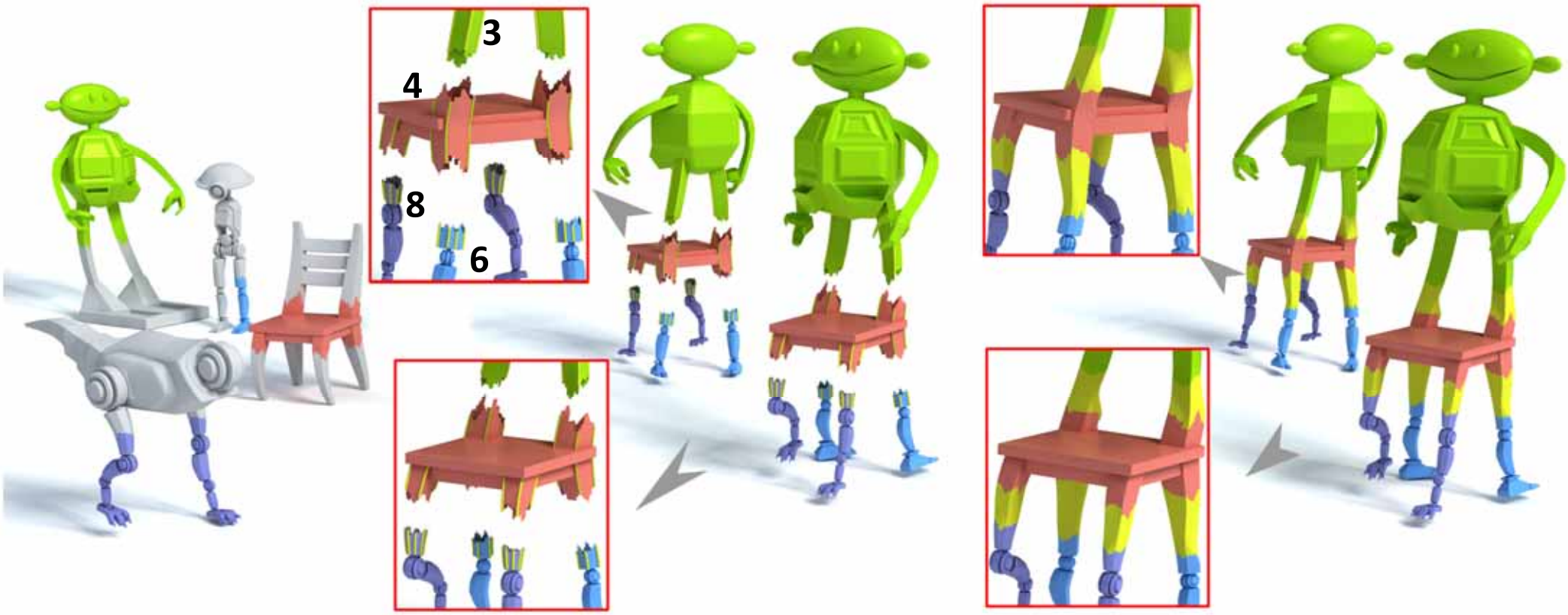


# Multiple Open Boundaries

# Partial overlapping

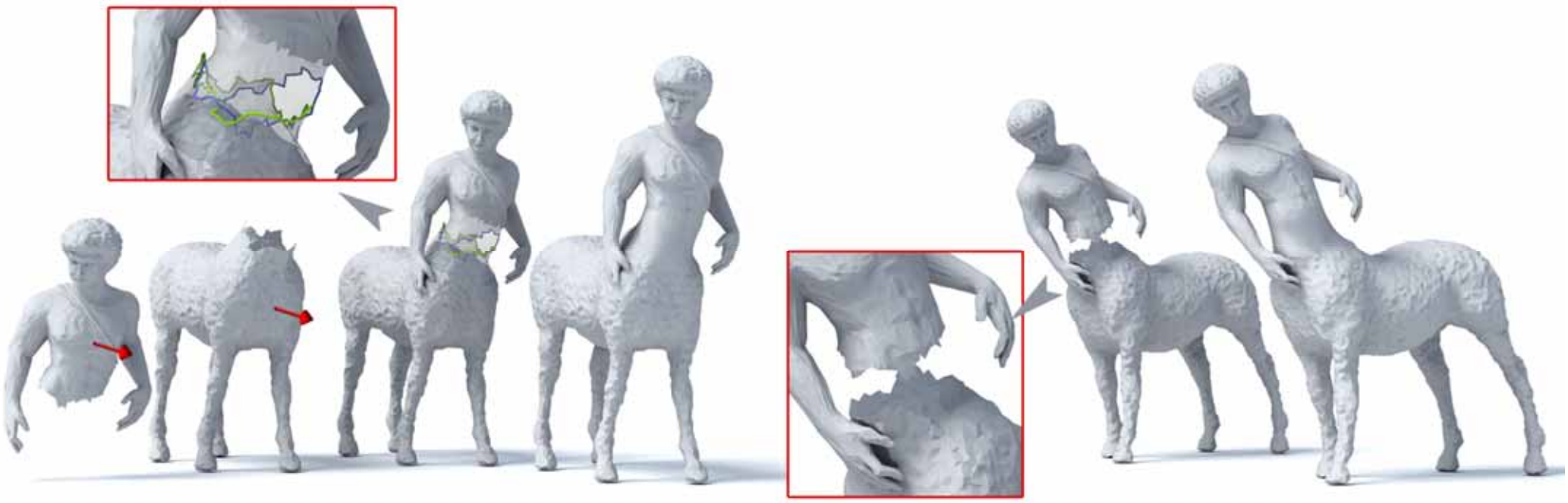


# Mismatched features



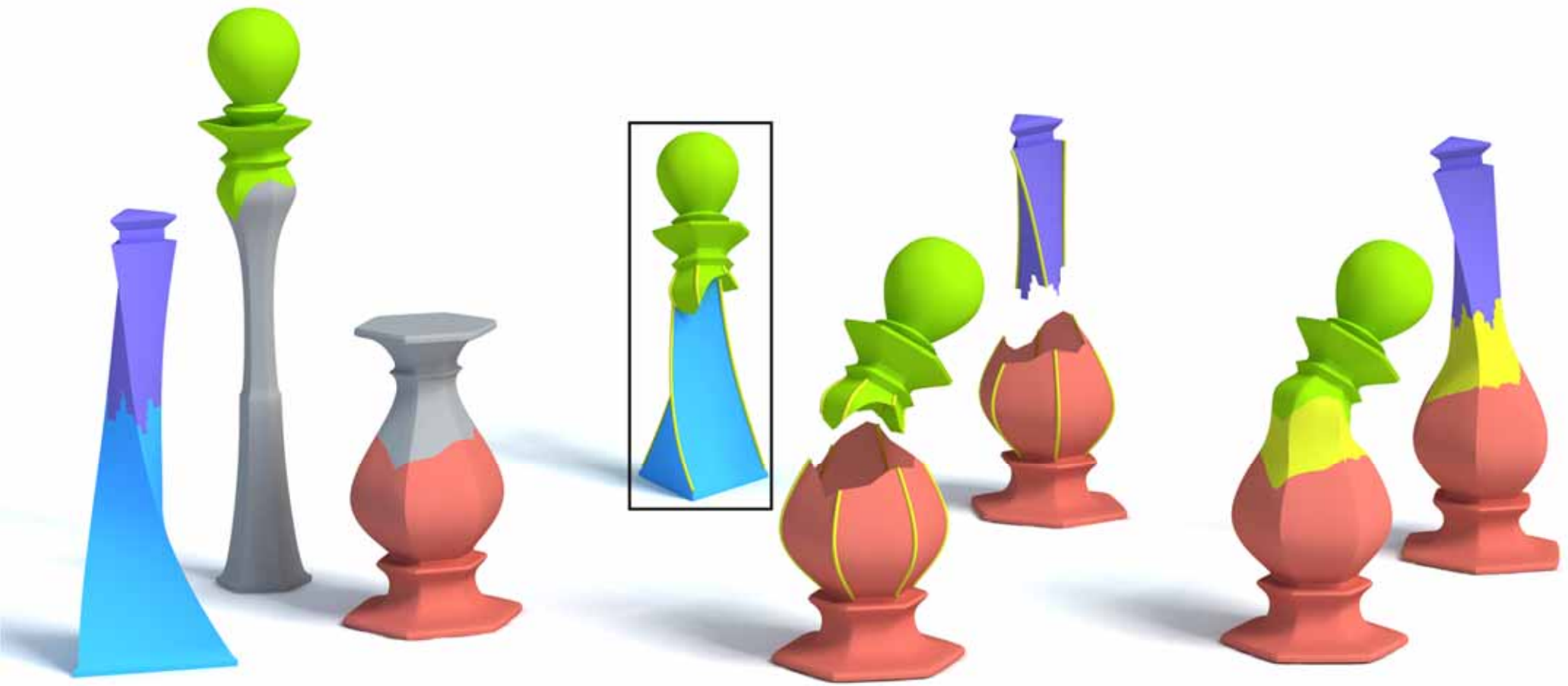
# Noisy parts and multiple open boundaries

# Enforcing alignment constraints



- Can be incorporated with additional alignment constraints given by the user
- Desirable when consider model semantics

# Limitations

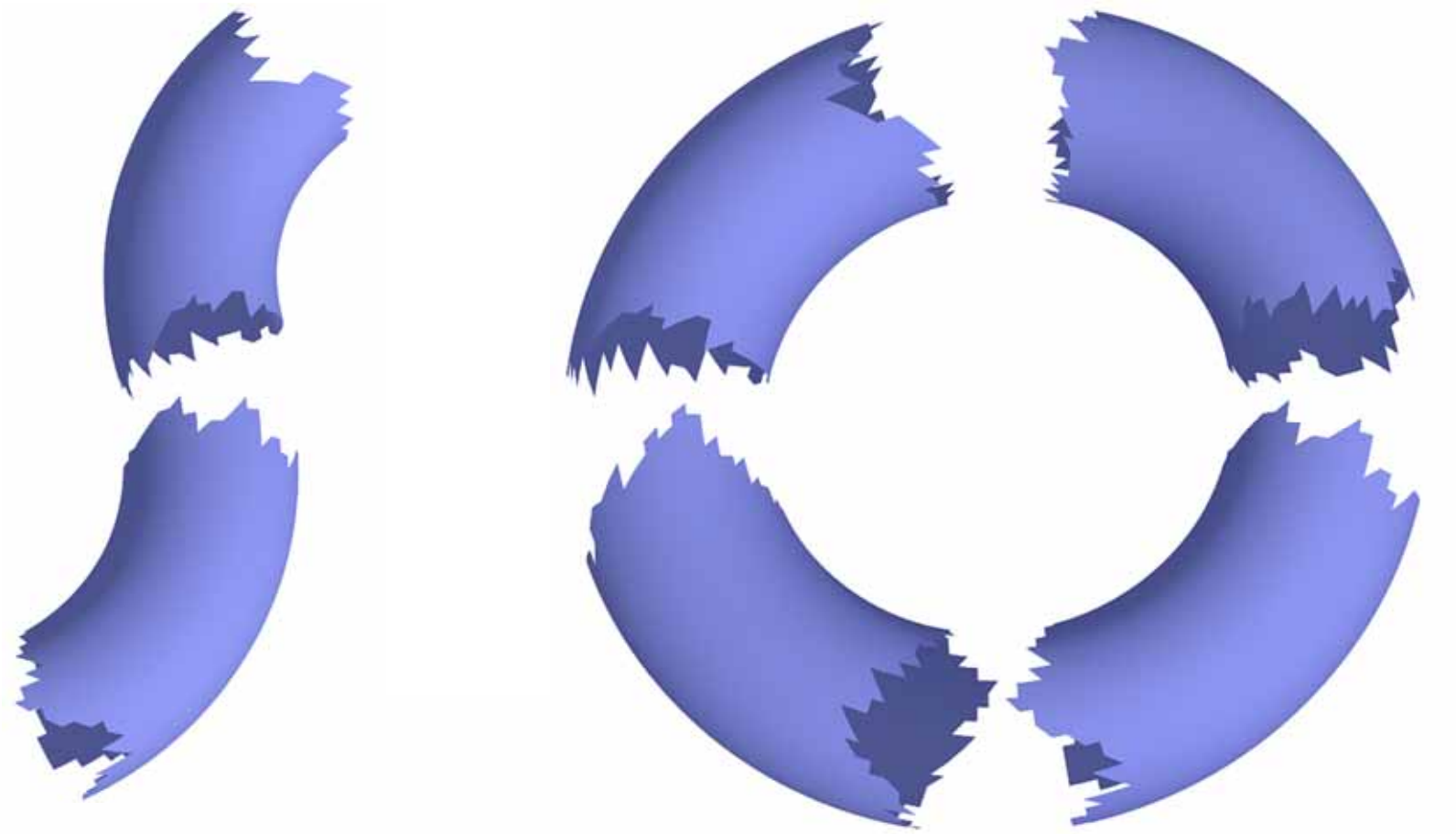


# Conclusions

- Align two parts through **ambient field continuation** and **surface-to-field registration**
- **Do not require** the parts to conform to each other, nor to have an overlap
- Compose parts together while respecting their sharp features, forming a composition using **piecewise smooth surfaces**

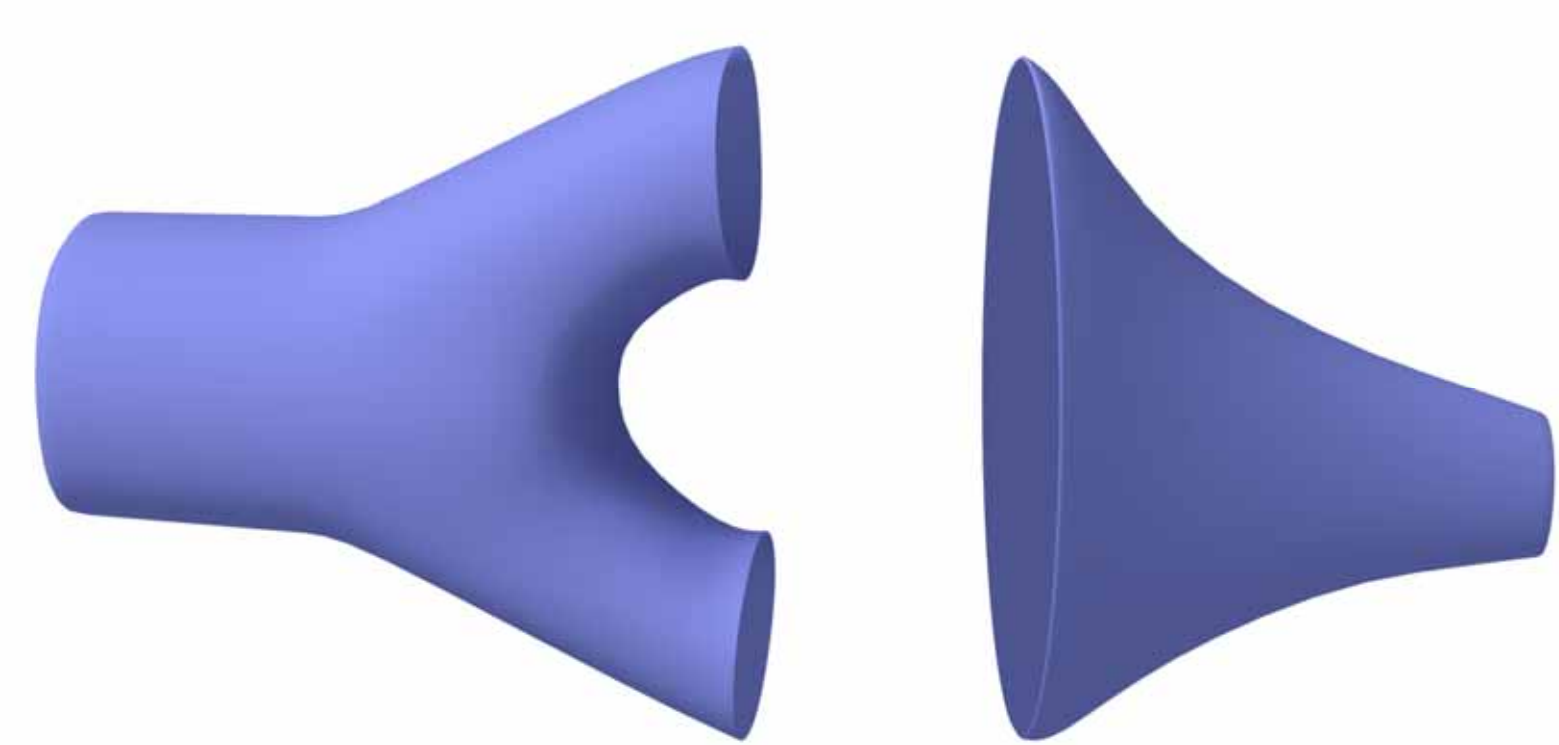
# Future work

- Register **multiple parts**



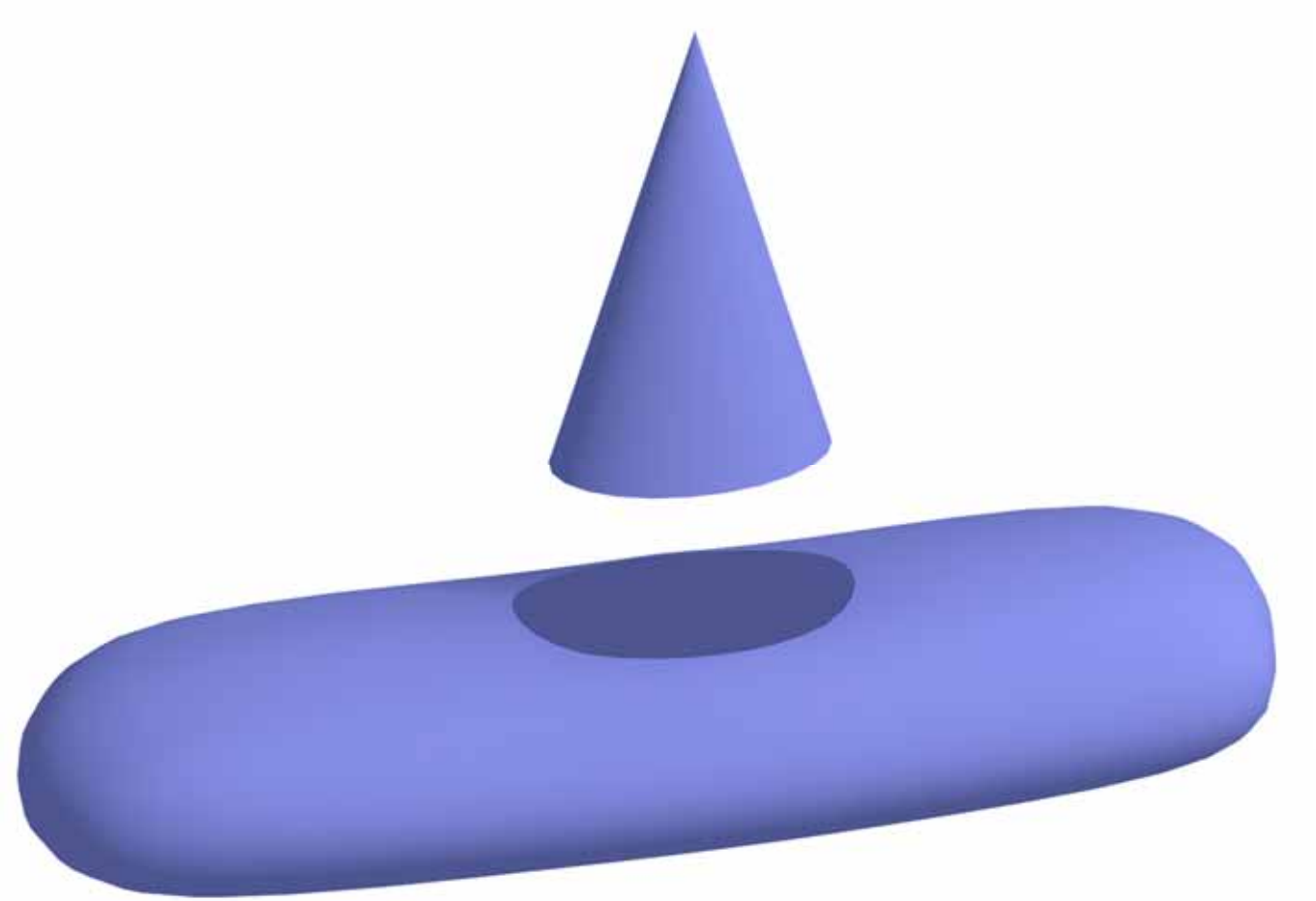
# Future work

- Handle **more complicate topologies** of the parts or boundaries



# Future work

- Other **criteria for tele-registration**?



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# Tele-registration

# Thank you!