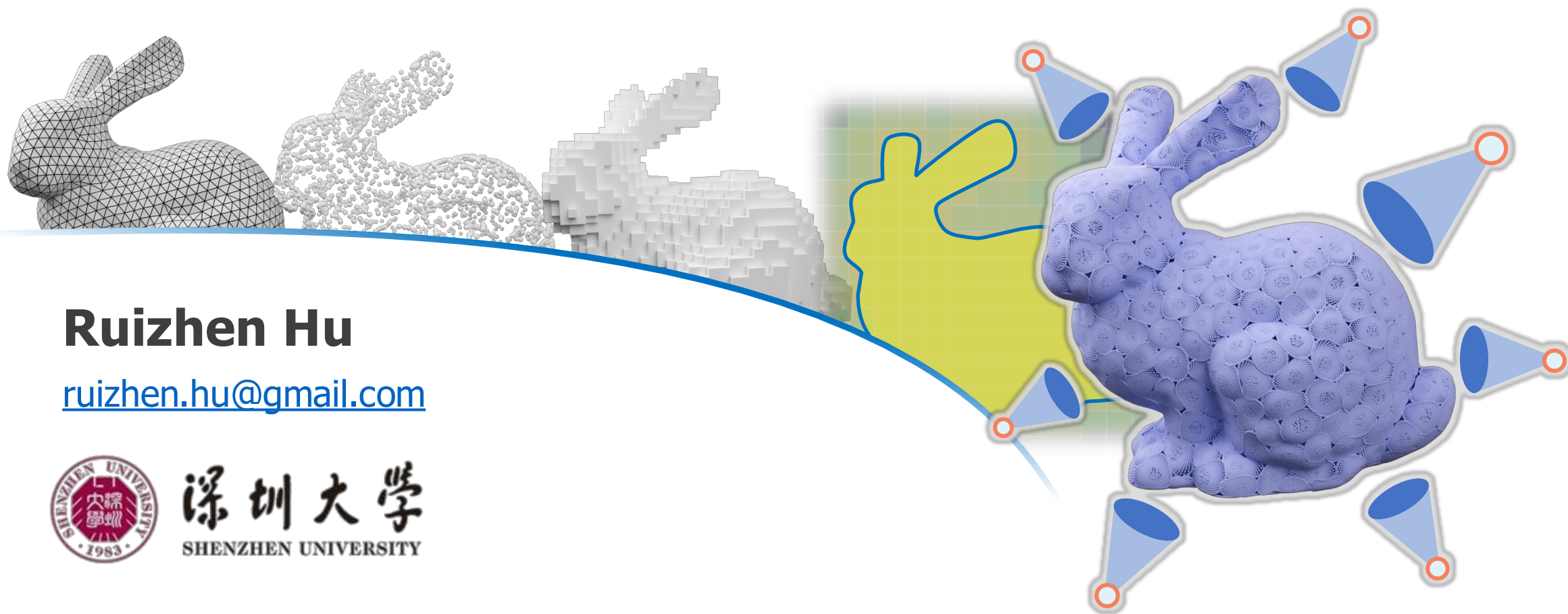


MASH: **M**asked **A**nchored **S**p**H**erical Distances - Towards a More Compact 3D Shape Representation



Ruizhen Hu

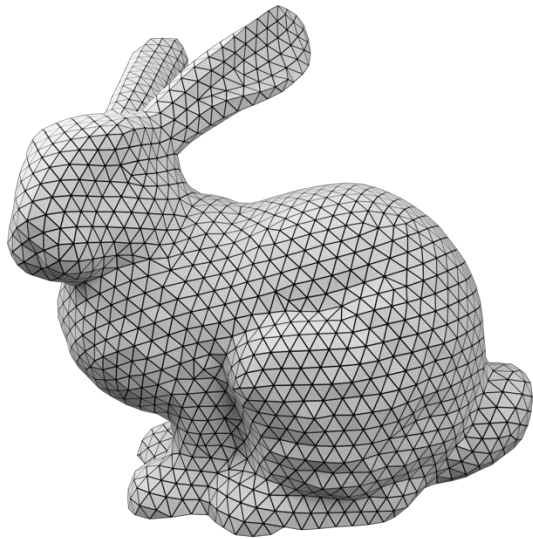
ruizhen.hu@gmail.com



深圳大学
SHENZHEN UNIVERSITY

3D Shape Representation

Mesh

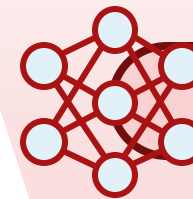


Interpretability

Editability

Representability

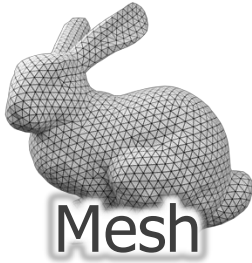
Compactness



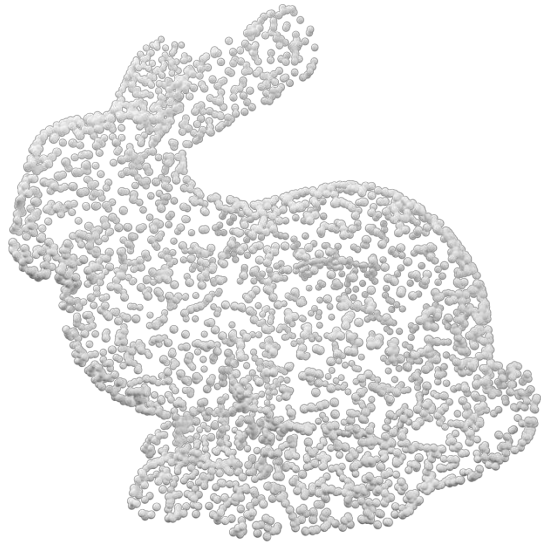
Regularity



3D Shape Representation



Point cloud



Interpretability

Editability

Regularity

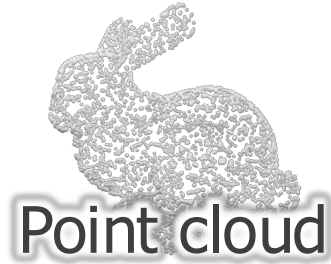
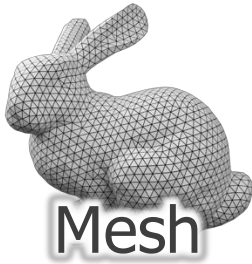


Representability

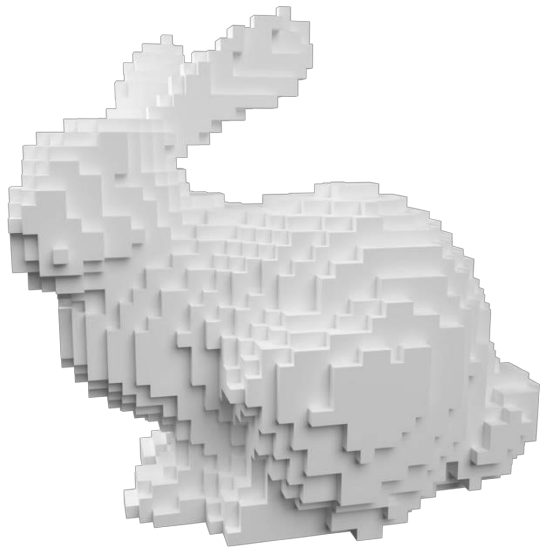
Compactness



3D Shape Representation



Voxel



Interpretability

Editability

Regularity

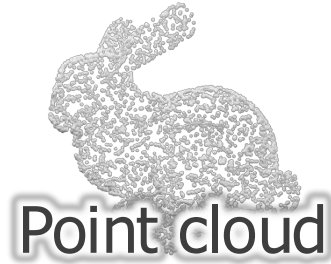
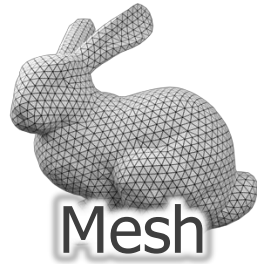


Representability

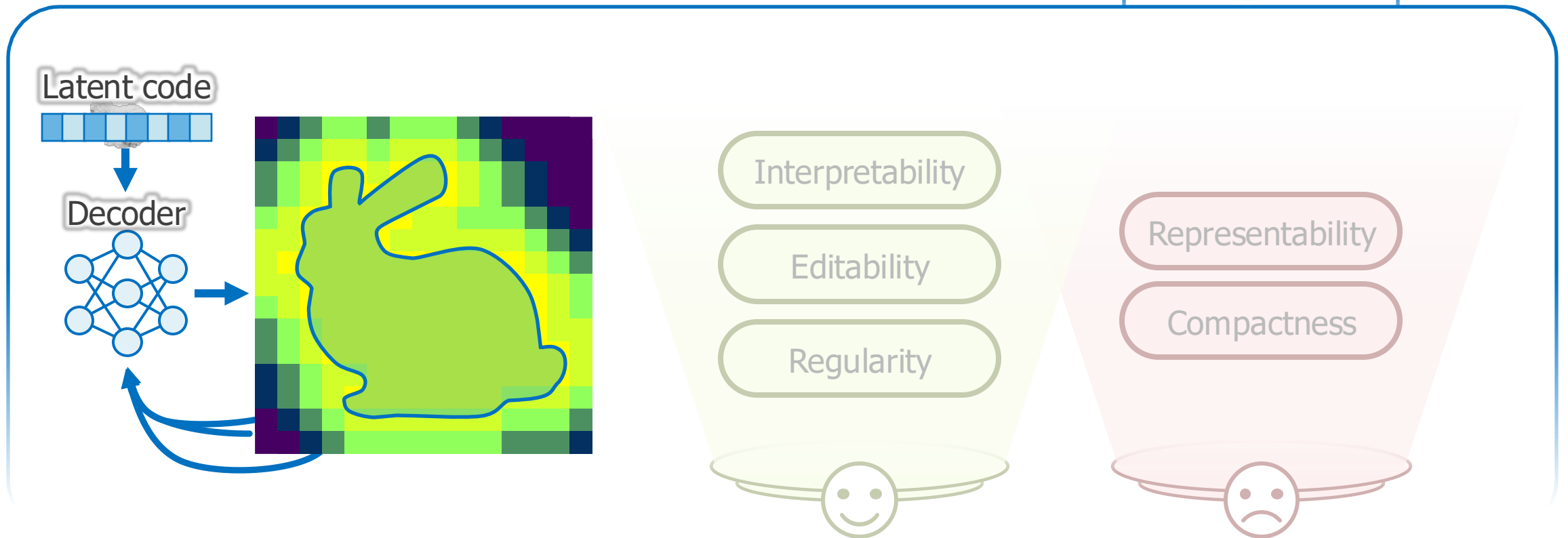
Compactness



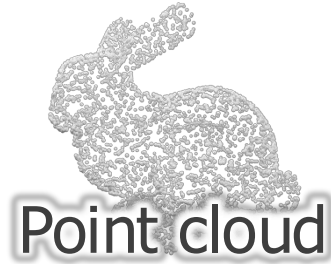
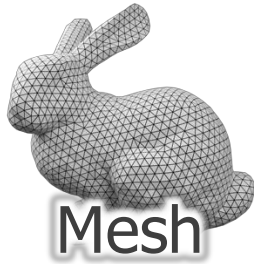
3D Shape Representation



Implicit



3D Shape Representation

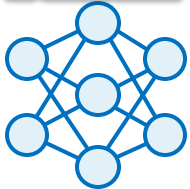


Implicit

Latent code



Decoder



Representability

Compactness

Regularity

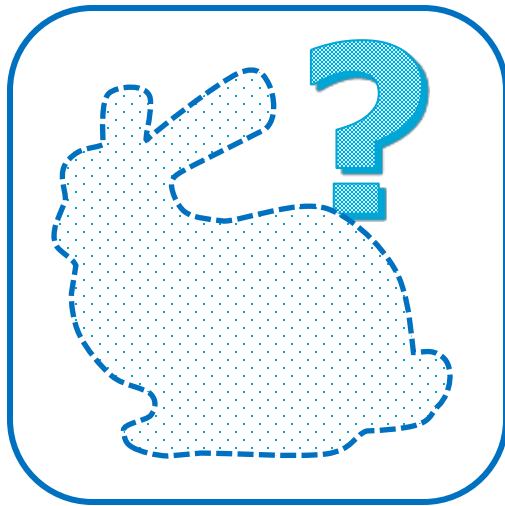
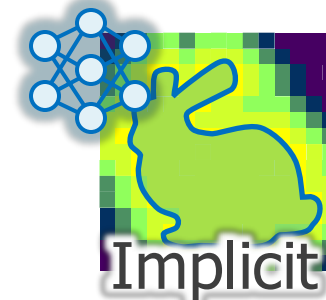
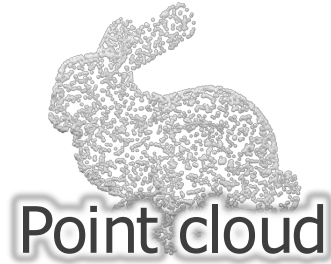
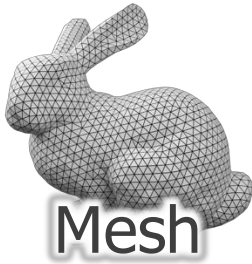


Interpretability

Editability



3D Shape Representation

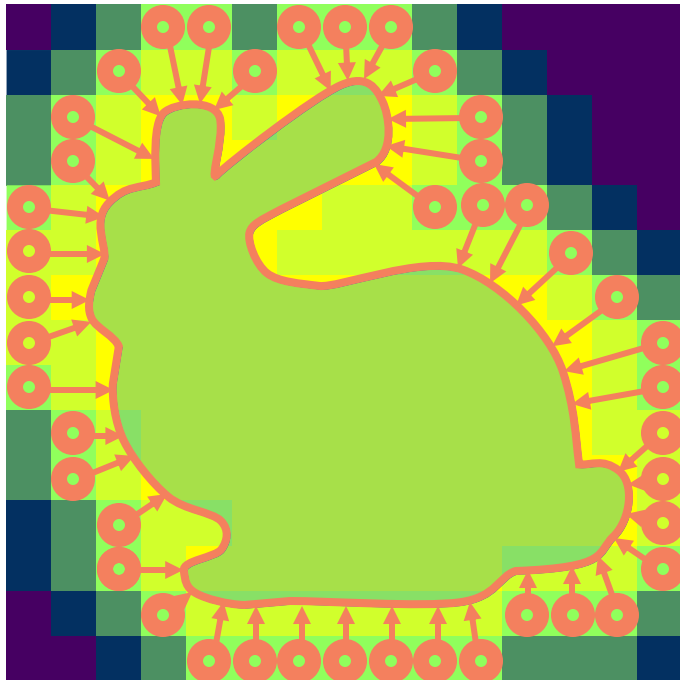


- Representability
- Compactness
- Regularity
- Interpretability
- Editability

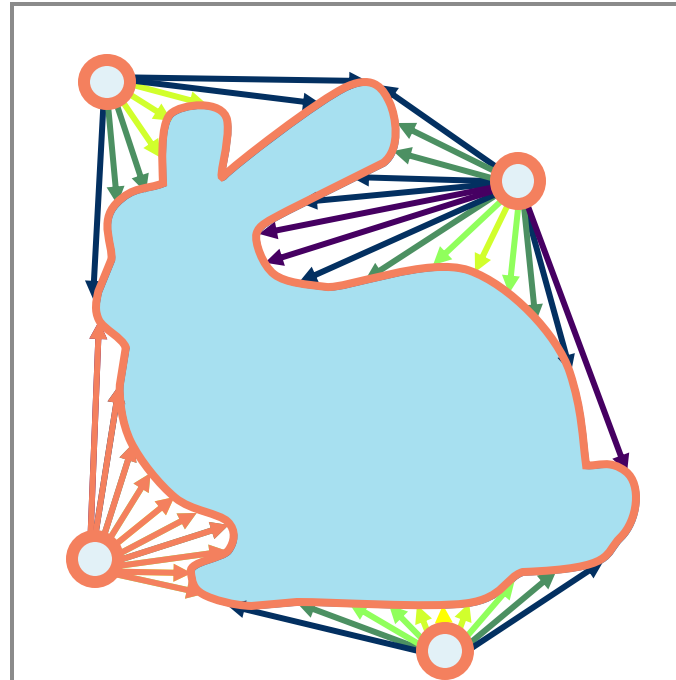


Key Idea: Turn Implicit To Compact Explicit

Signed Distance Field



MASH: Masked Anchored SpHerical Distances



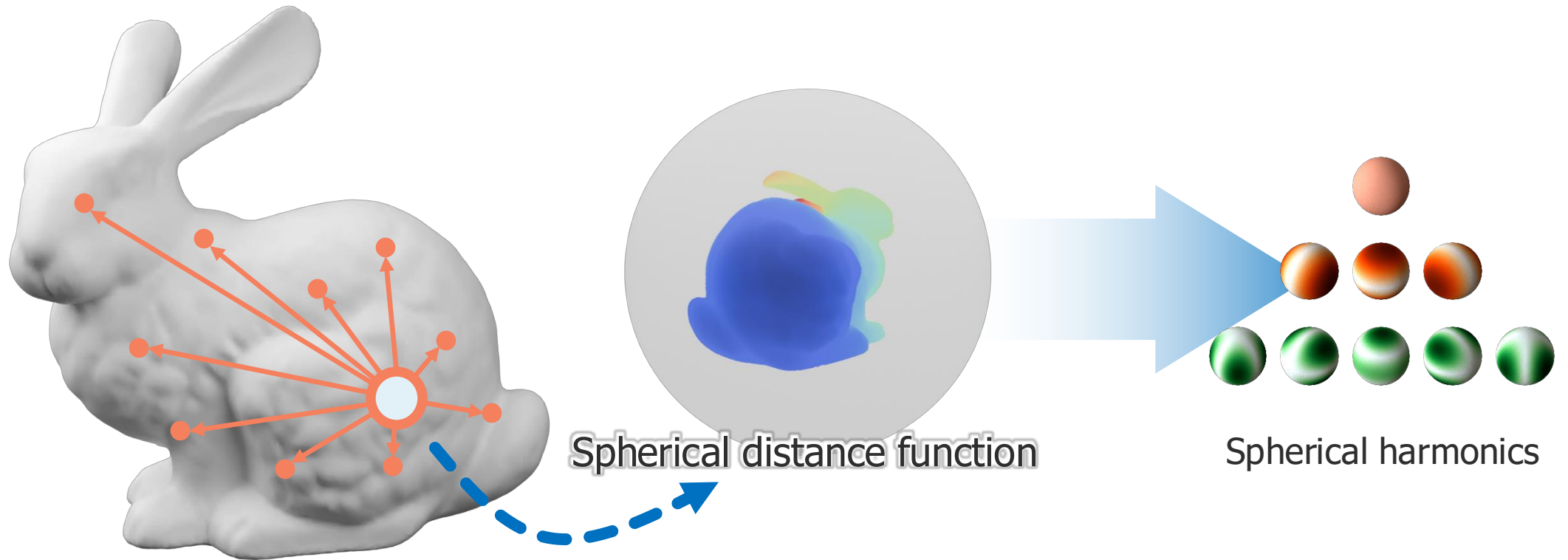
1 MASH Representation

How to parametrize each anchored distance function effectively?

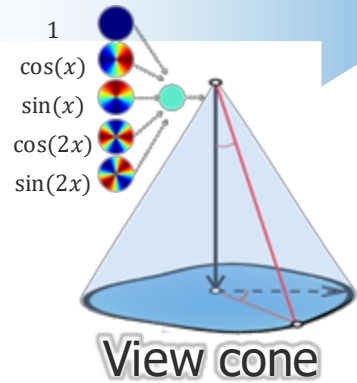
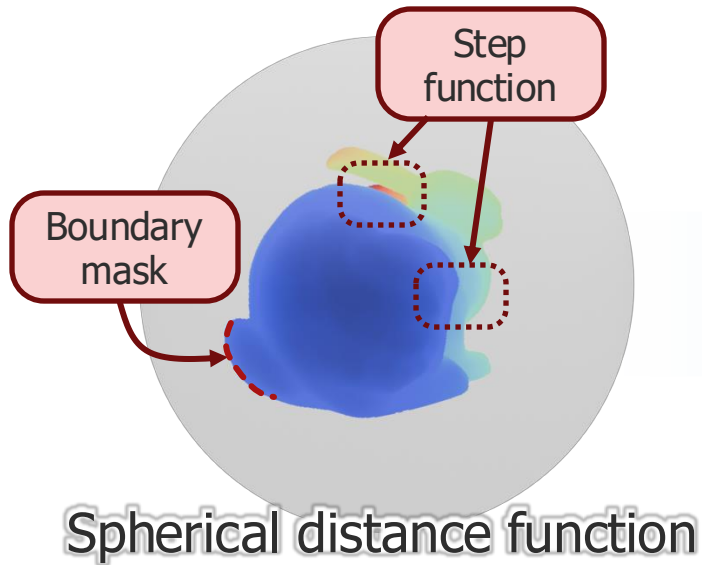
2 MASH Optimization

How to find the optimal MASH parameterization for a shape?

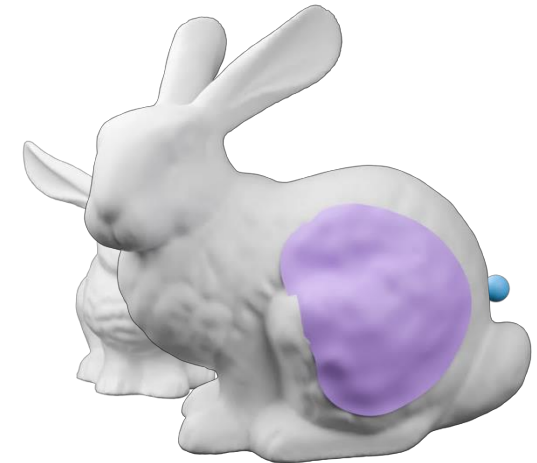
Challenge 1: MASH Representation



Challenge 1: MASH Representation

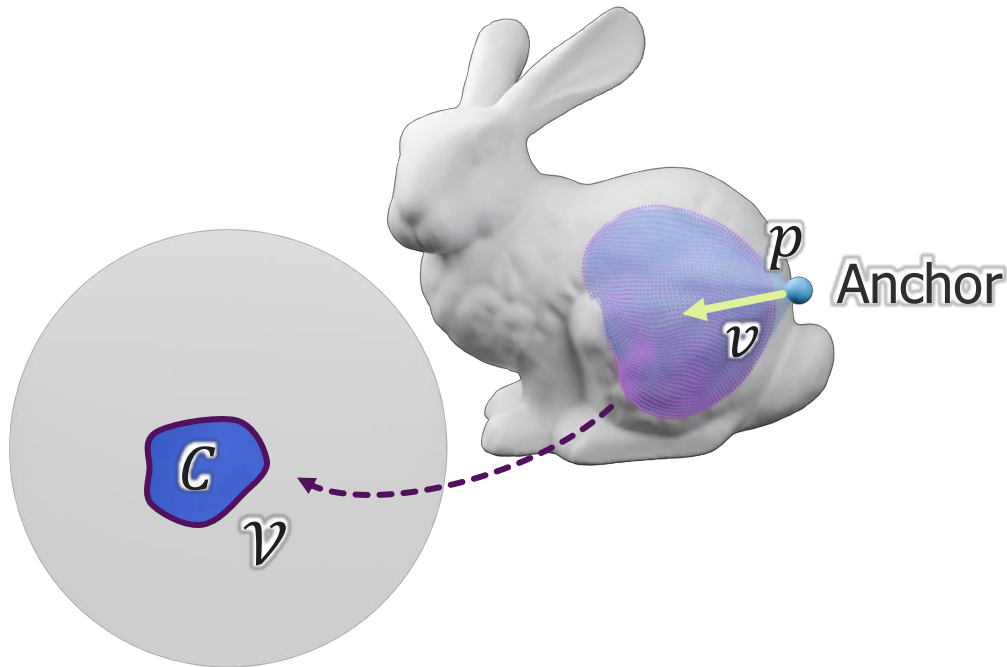


Hard to represent the surface patch accurately



MASH: Masked Anchored Spherical Distances

- Represent the masked spherical distance function compactly along with the **anchor**



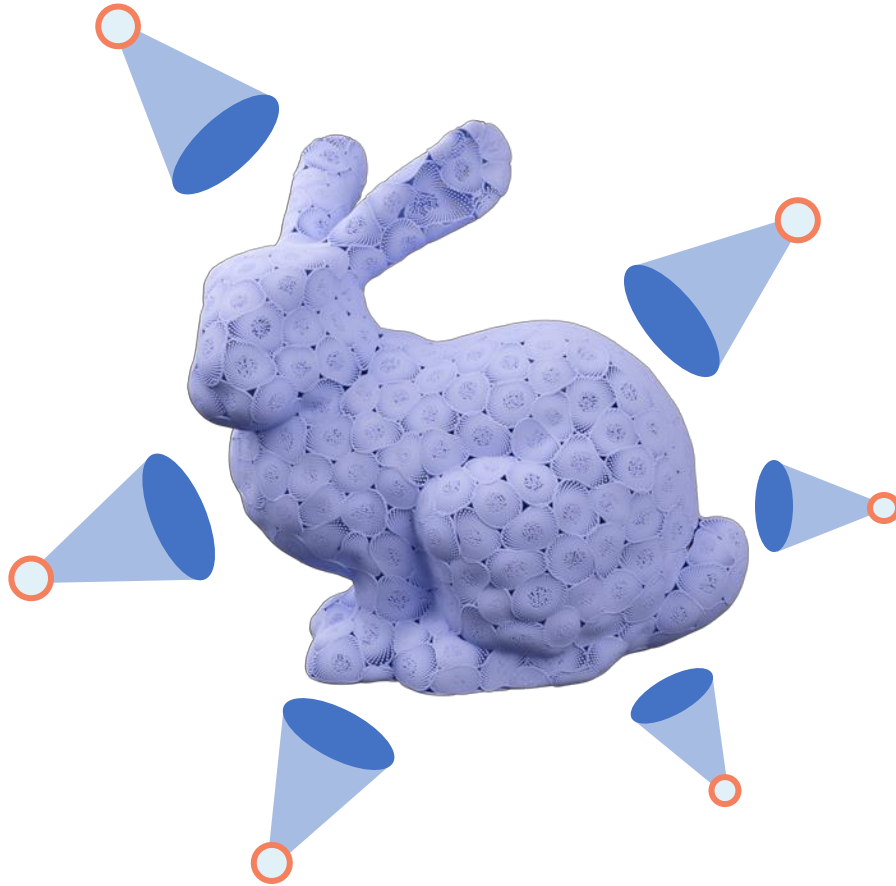
$$p = [x, y, z]$$

$$v = [n_x, n_y, n_z]$$

$$C = \{C_l^m \mid |m| \leq l, l = 0, 1, \dots, L\}$$

$$\mathcal{V} = \{a_0, a_1, b_1, \dots, a_K, b_K\}$$

Challenge 2: MASH Optimization



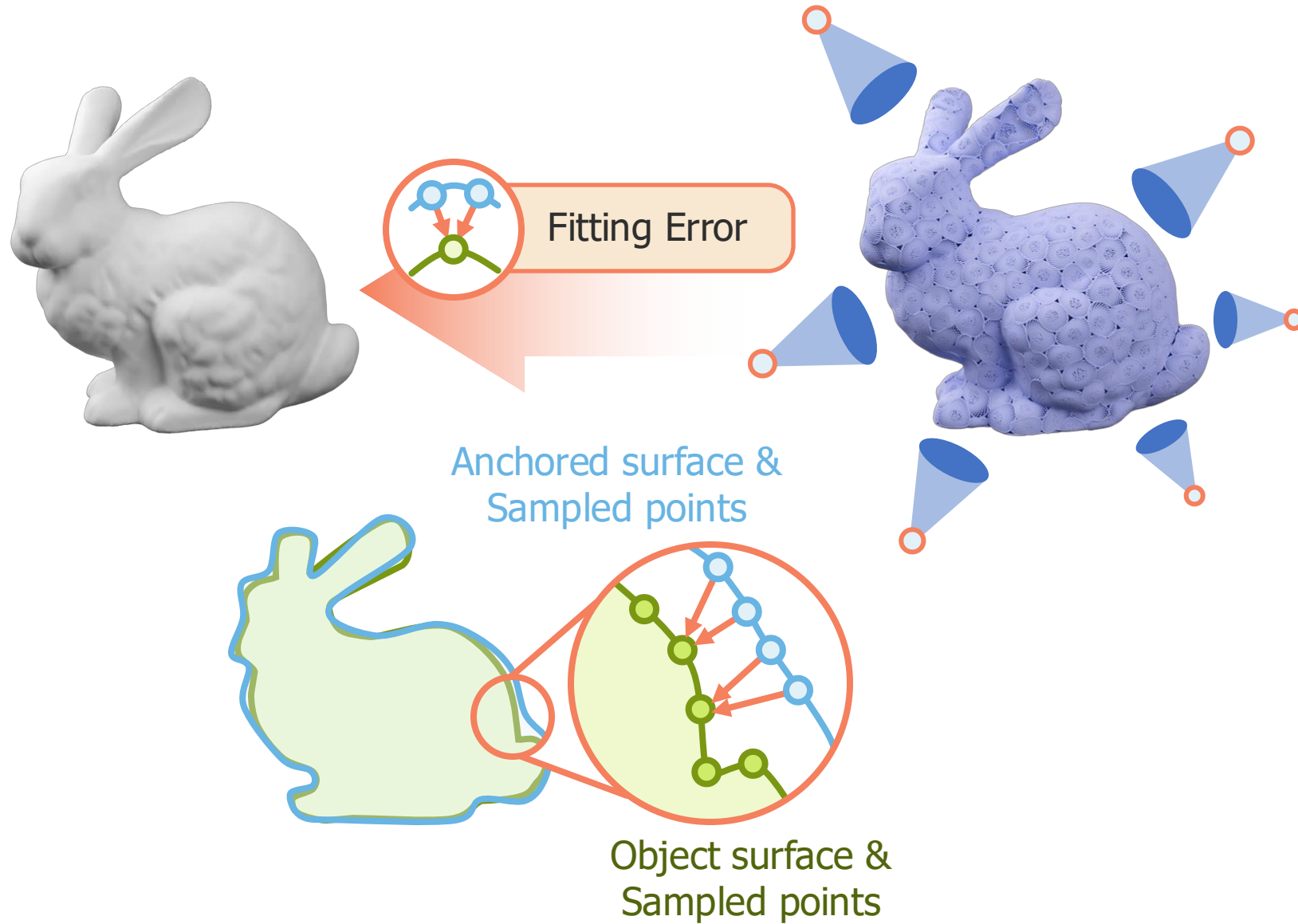
$$p = [x, y, z]$$

$$v = [n_x, n_y, n_z]$$

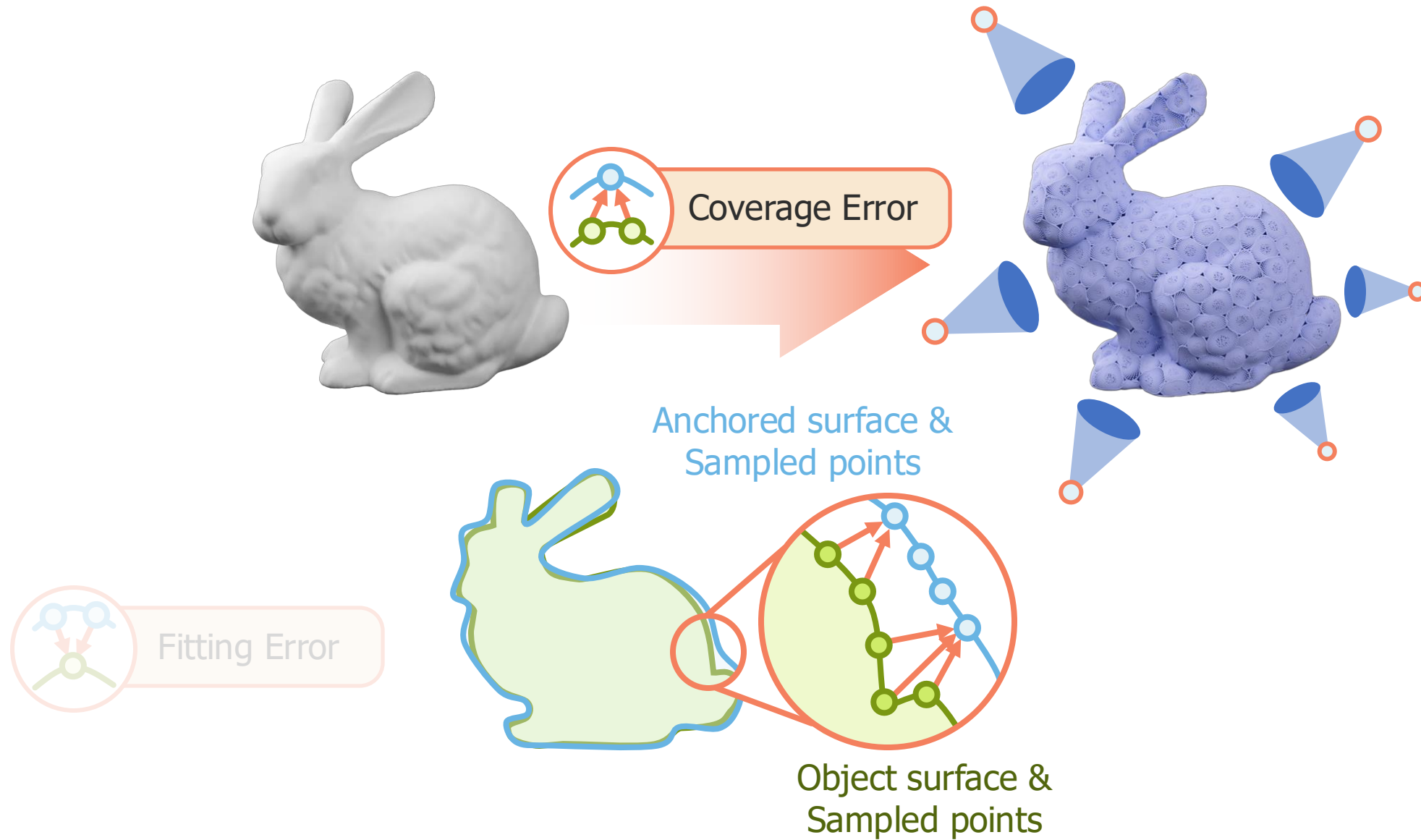
$$C = \{C_l^m \mid |m| \leq l, l = 0, 1, \dots, L\}$$

$$\mathcal{V} = \{a_0, a_1, b_1, \dots, a_K, b_K\}$$

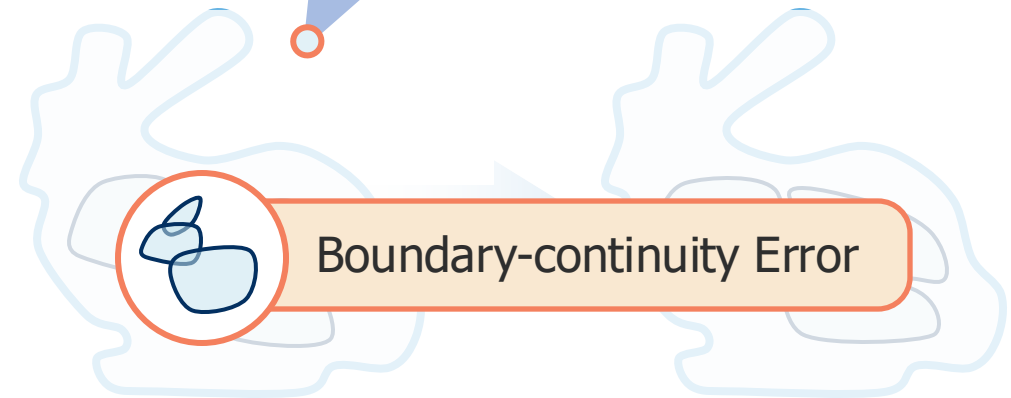
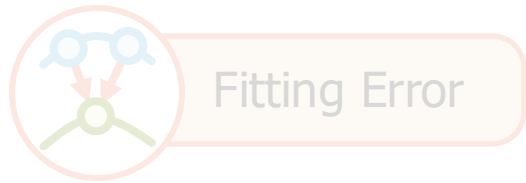
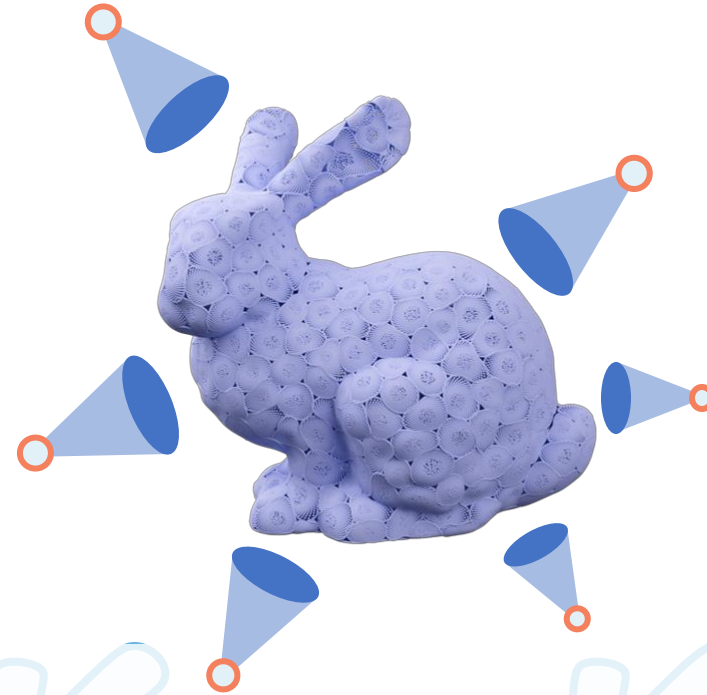
Objective Function



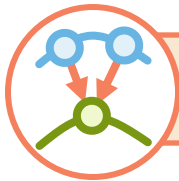
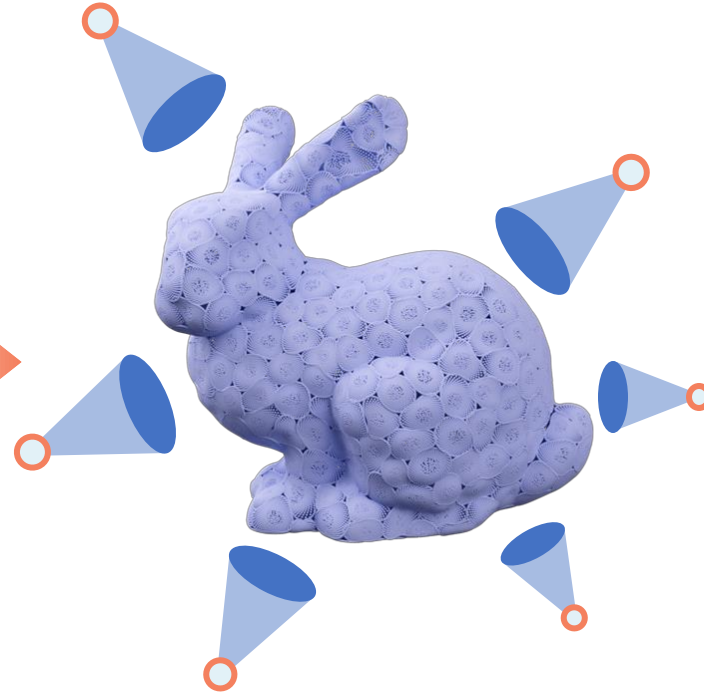
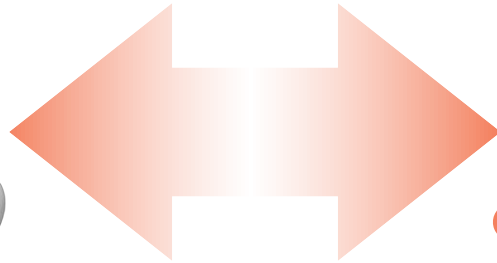
Objective Function



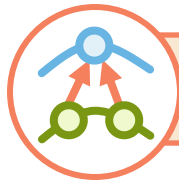
Objective Function



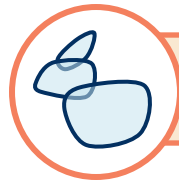
Objective Function



Fitting Error



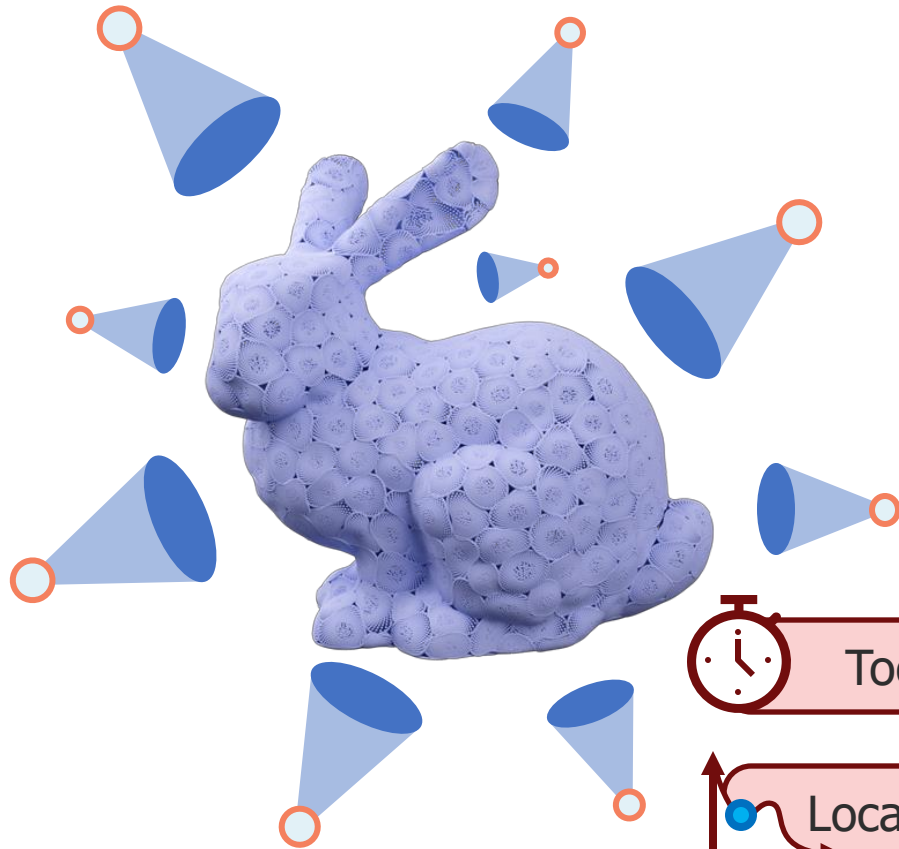
Coverage Error



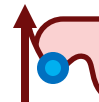
Boundary-continuous Error

How to Optimize?

Sample-based MASH Optimization



Too slow

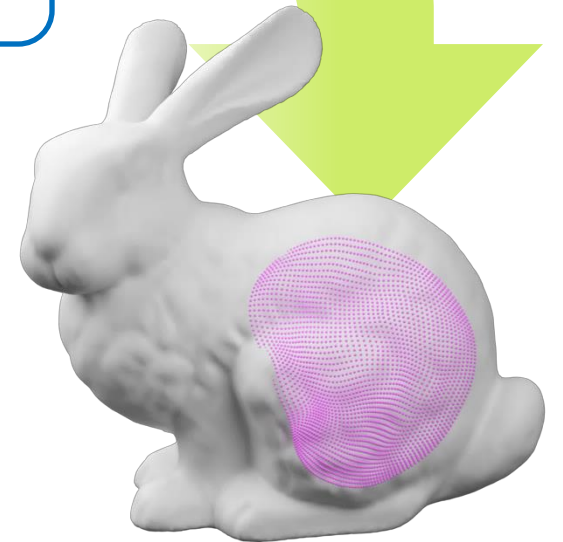
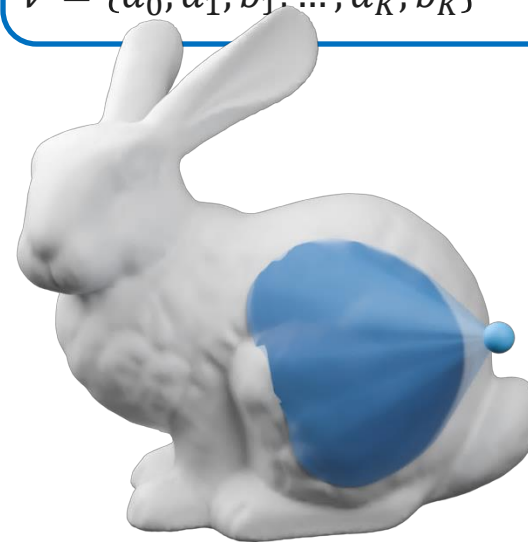


Local minima

Differentiable MASH Point Sampling

$$p = [x, y, z]$$
$$v = [n_x, n_y, n_z]$$
$$C = \{C_l^m \mid |m| \leq l, l = 0, 1, \dots, L\}$$
$$\mathcal{V} = \{a_0, a_1, b_1, \dots, a_K, b_K\}$$

Parameterization



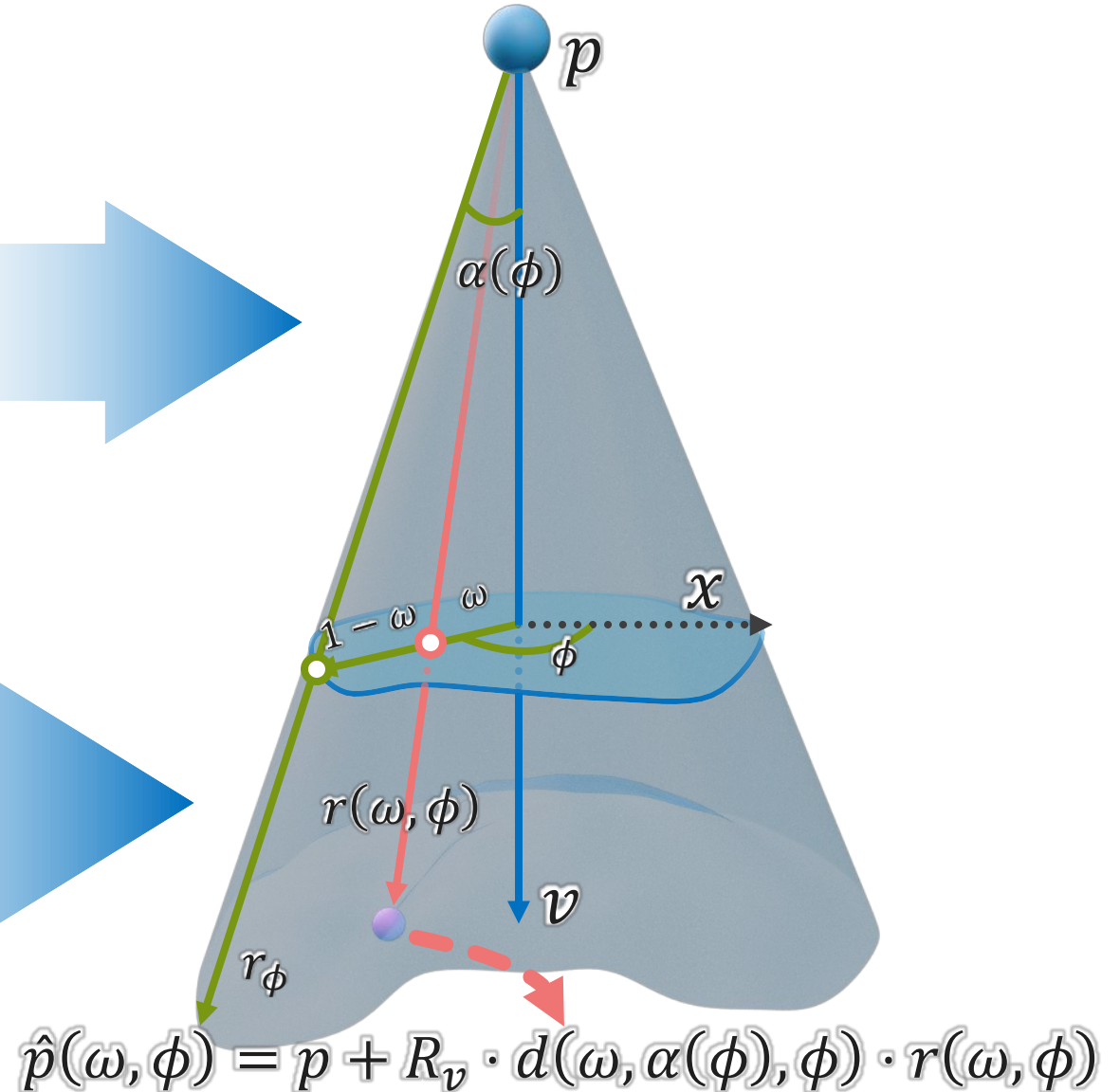
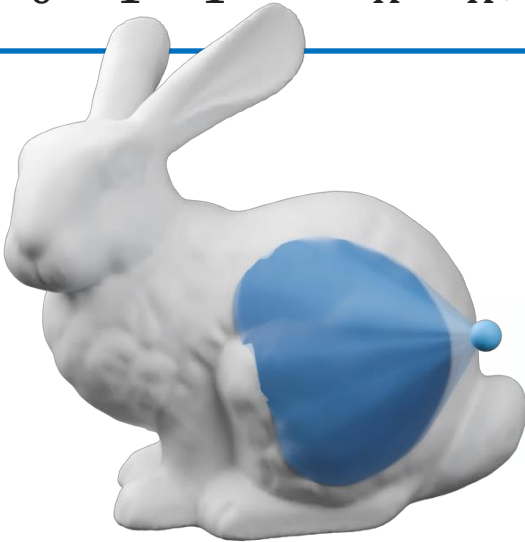
Differentiable MASH Point Sampling

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$$C = \{C_l^m \mid |m| \leq l, l = 0, 1, \dots, L\}$$

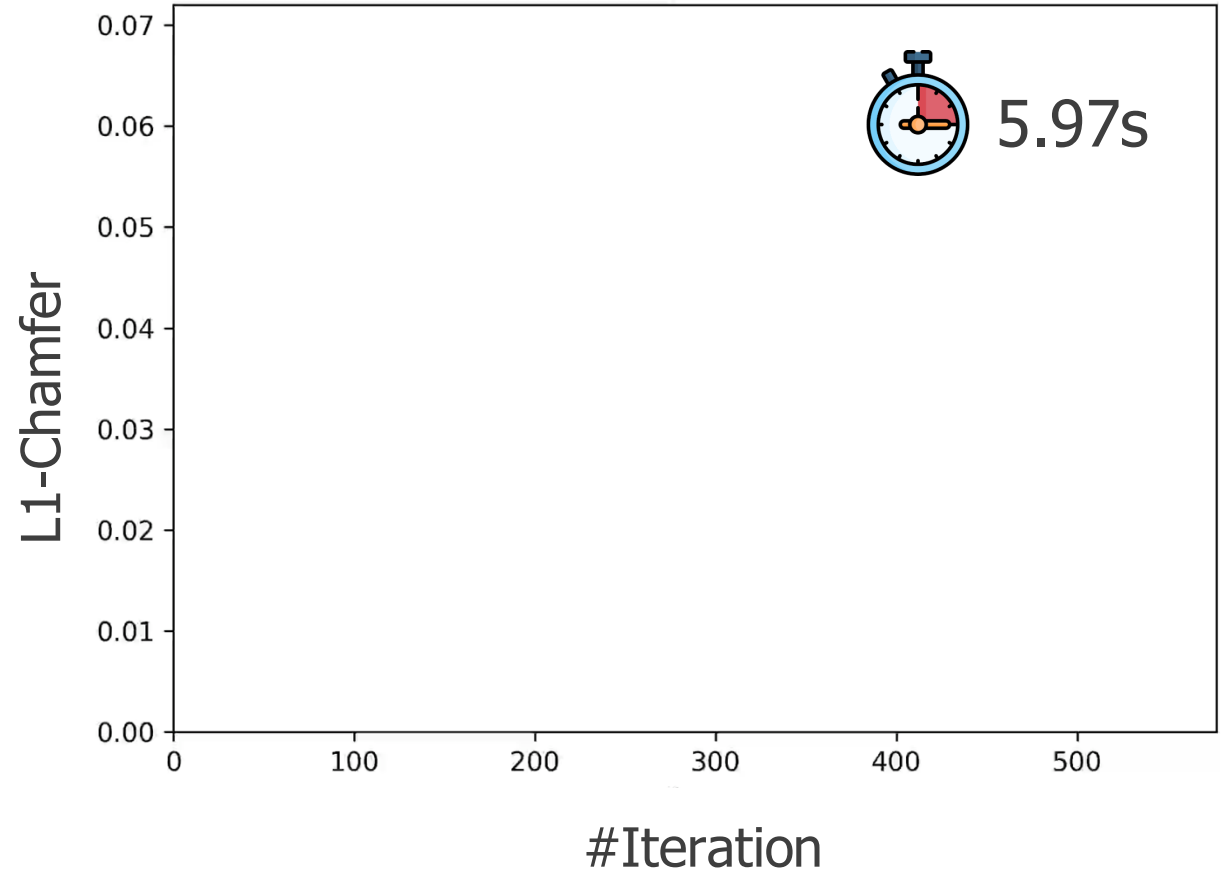
$$\mathcal{V} = \{a_0, a_1, b_1, \dots, a_K, b_K\}$$



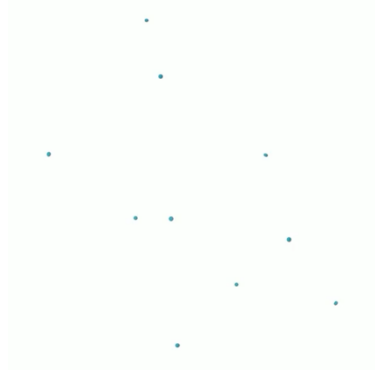
Differentiable Optimization



#Anchor = 50



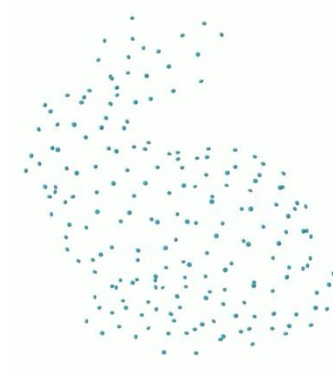
Differentiable Optimization



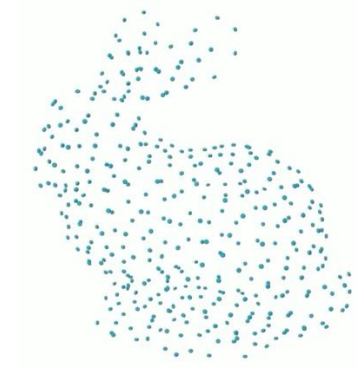
#Anchor = 10



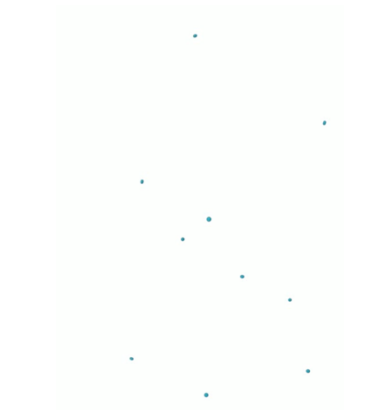
#Anchor = 50



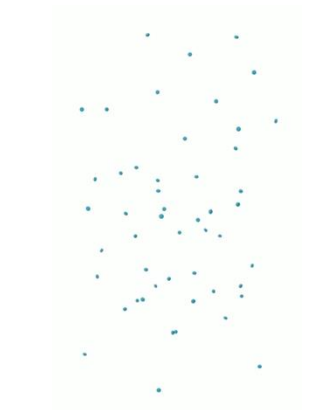
#Anchor = 200



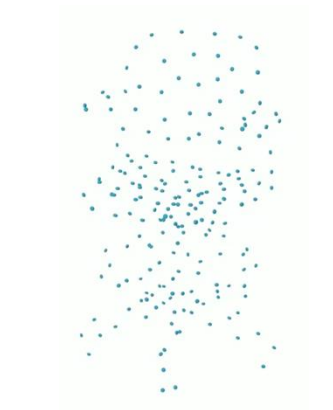
#Anchor = 400



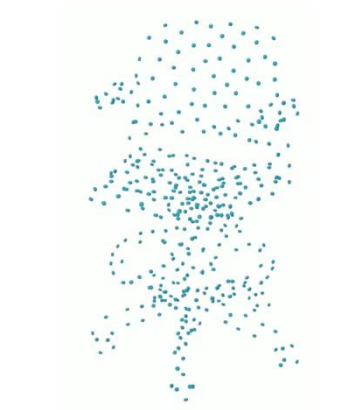
#Anchor = 10



#Anchor = 50



#Anchor = 200



#Anchor = 400

Representability

for Complex Shapes



MASH optimization results of shapes with **inner structure**

Representability

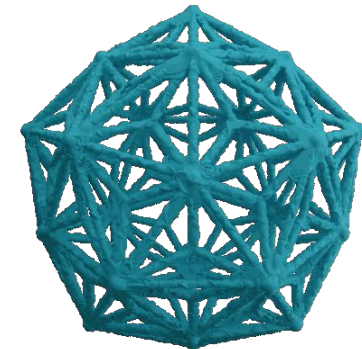
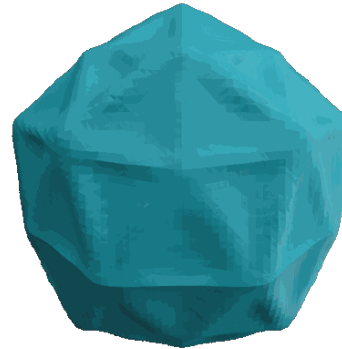
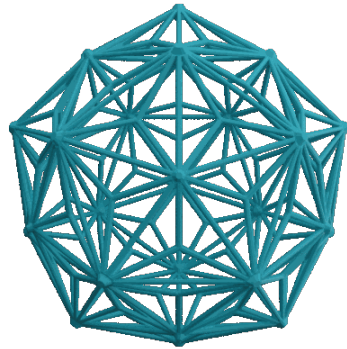
for Complex Shapes

GT

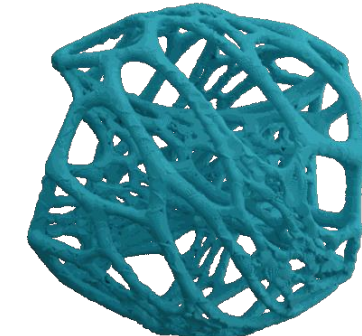
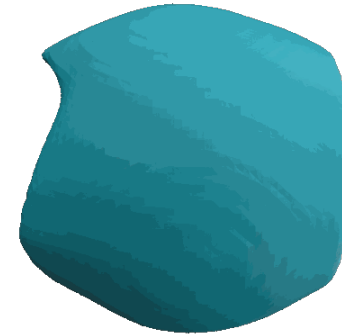
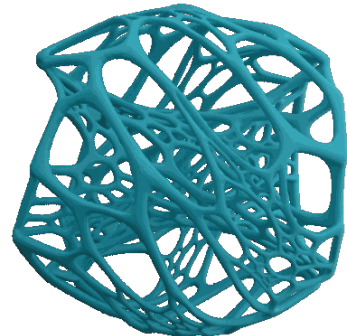
Latent Set
[Zhang et al. 2023]

MASH

Thingi10K
Model 46602

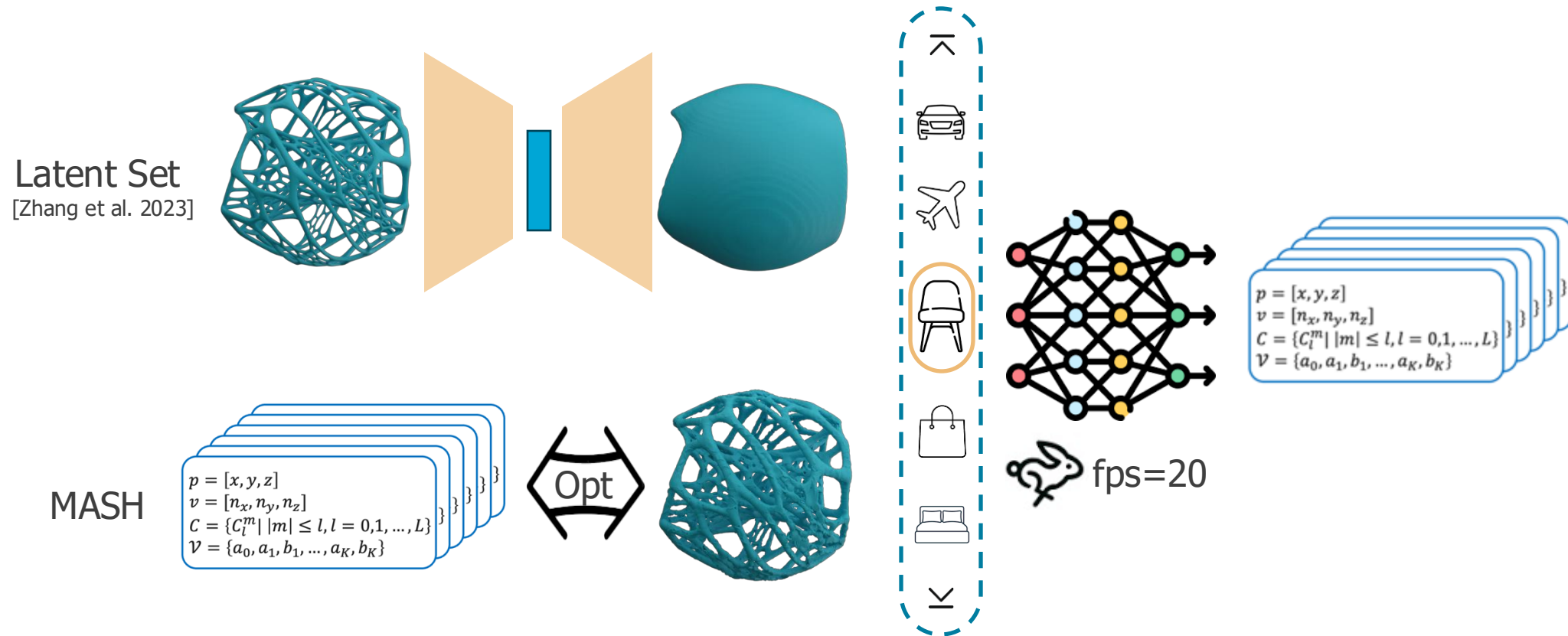


Thingi10K
Model 61258



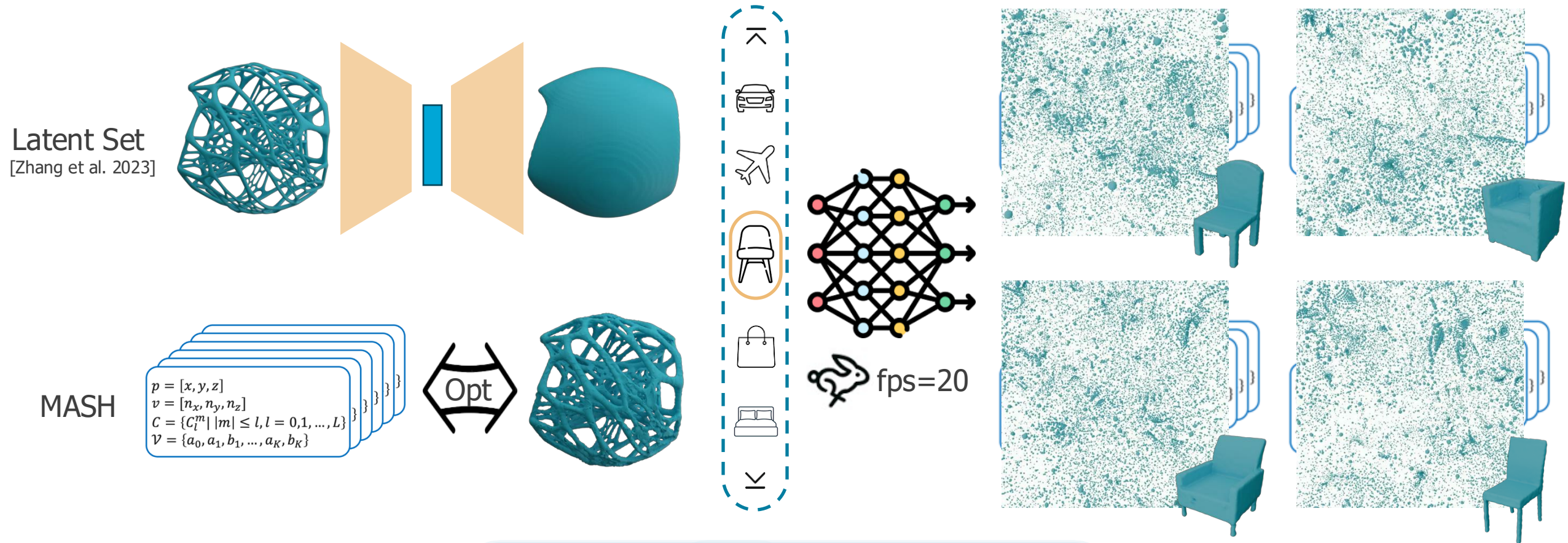
MASH optimization results of shapes with **high genus**

Regularity & Compactness for Shape Generation



Efficient training and inference

Regularity & Compactness for Shape Generation

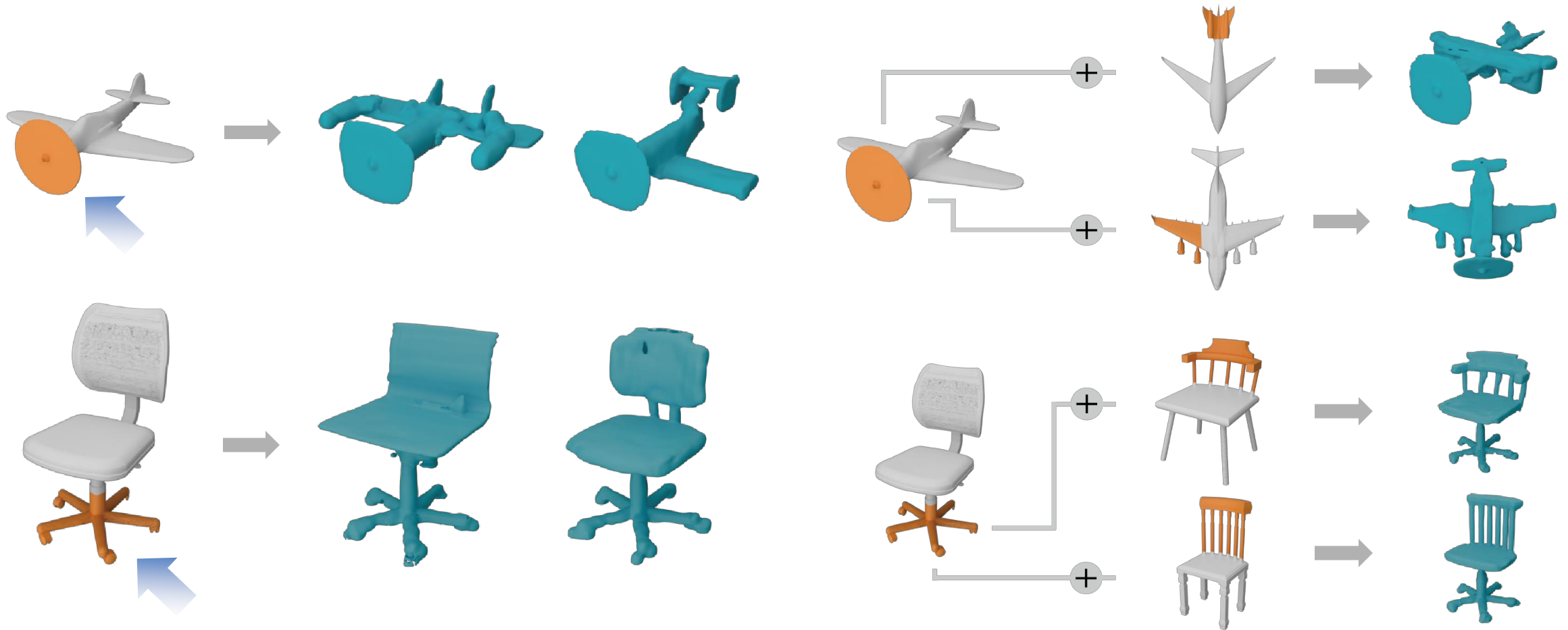


Explicit

Interpretability

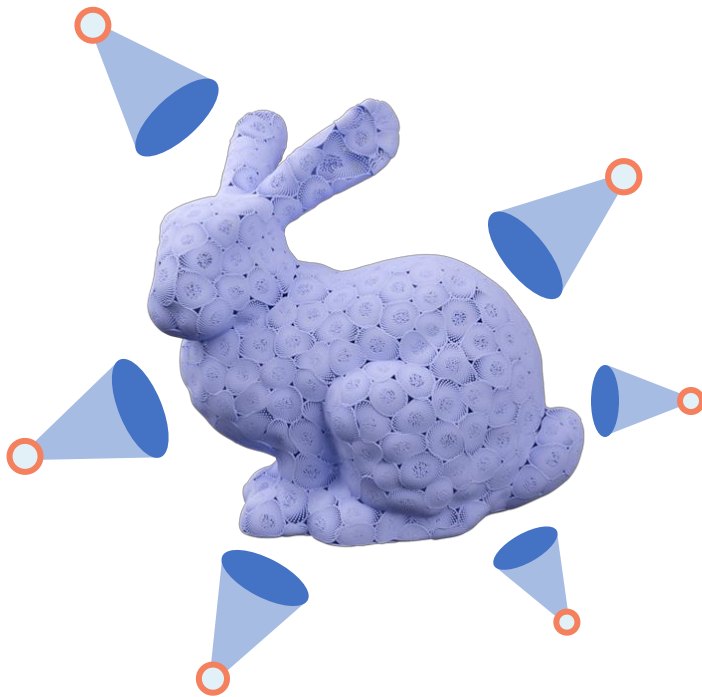
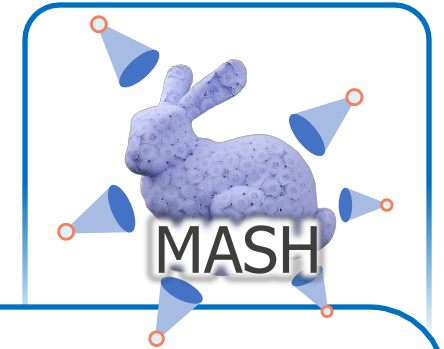
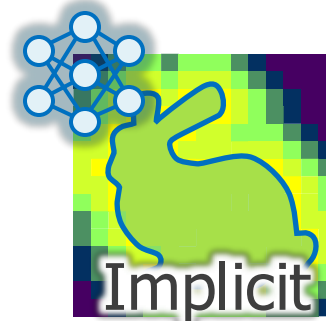
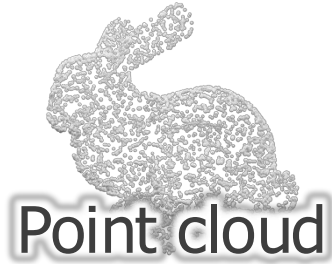
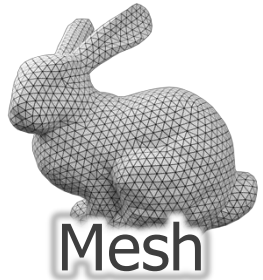
Supports

Editability



Part-conditioned shape **completion** and **blending**

3D Shape Representation

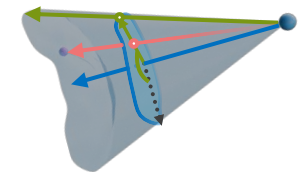
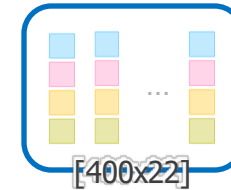


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$$\mathcal{V} = \{a_0, a_1, b_1, \dots, a_K, b_K\}$$

$$p = [x, y, z]$$

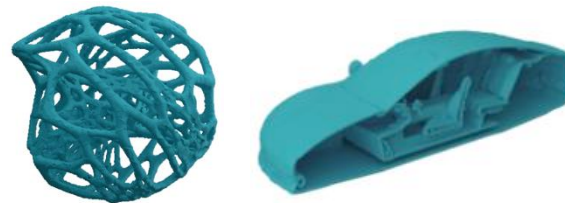
$$v = [n_x, n_y, n_z]$$



Compactness

Regularity

Interpretability



Representability

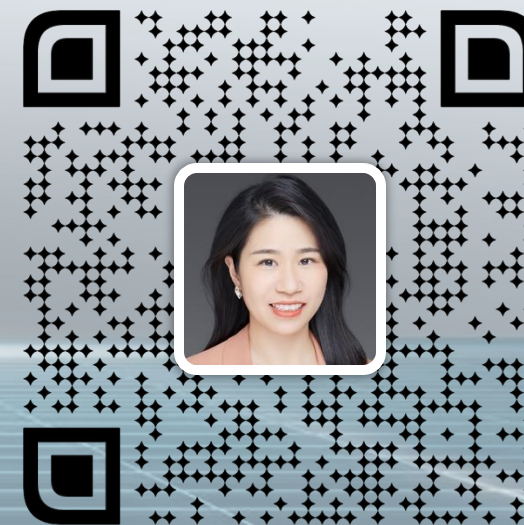


Editability

THANK YOU!

**MASH: Masked Anchored SpHpherical Distances
for 3D Shape Representation and Generation**

Changhao Li Yu Xin Xiaowei Zhou Ariel Shamir
Hao Zhang Ligang Liu Ruizhen Hu*



ruizhen.hu@gmail.com