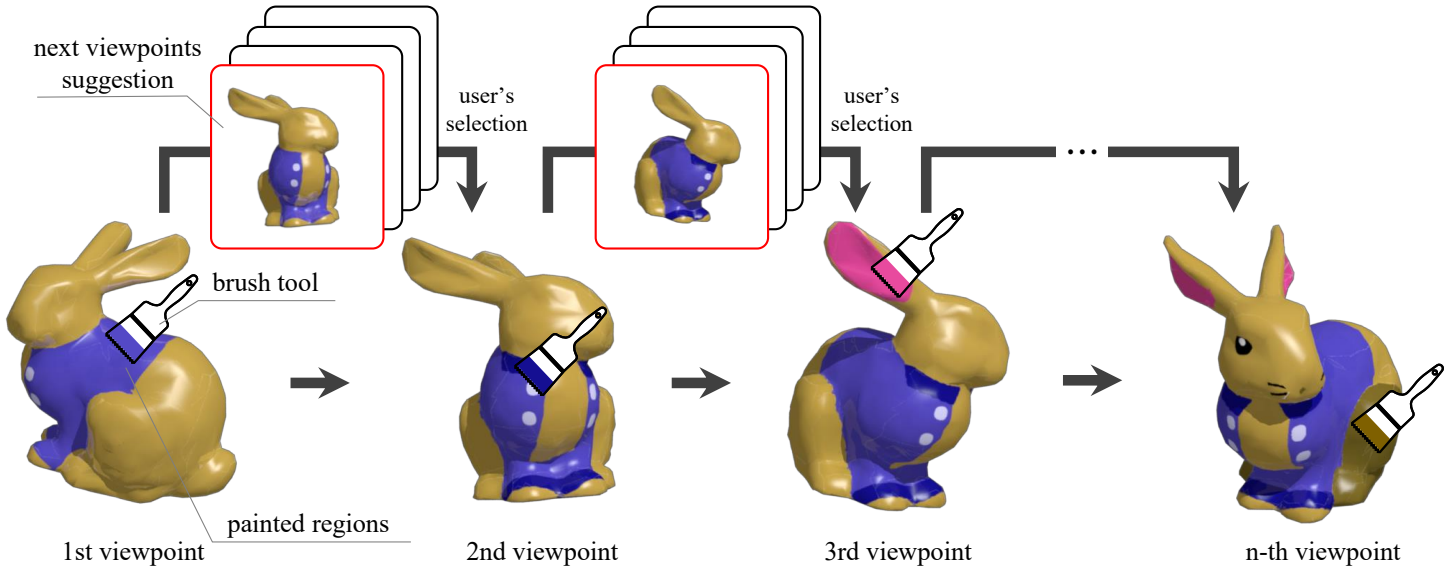
PaintersView: Automatic Suggestion of Optimal Viewpoints for 3D Texture Painting



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THE UNIVERSITY OF TOKYO

SIGGRAPH ASIA 2019 BRISBANE

- Intuitive 3D painting
- Rotate manually to desired viewpoint, paint until satisfied
- Rotate the model again and again

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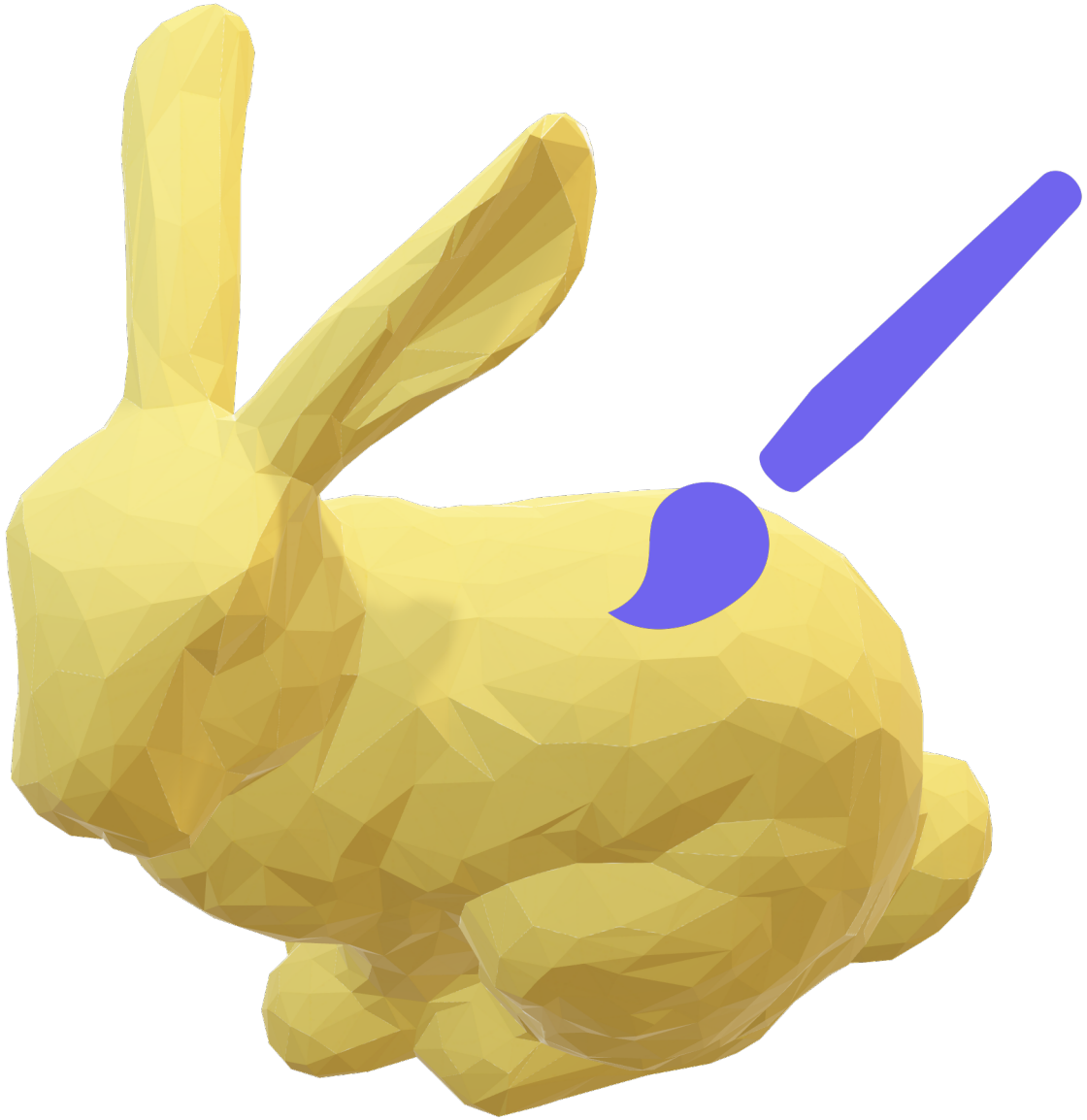

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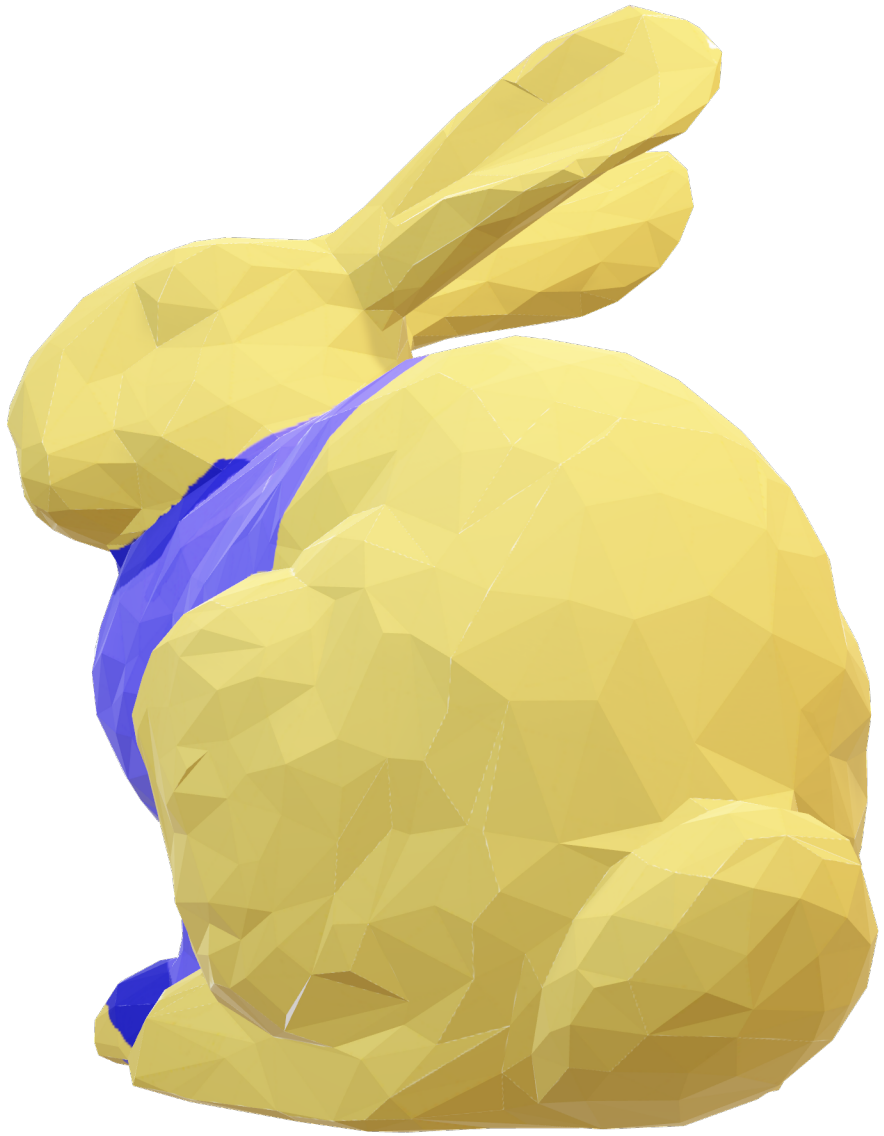

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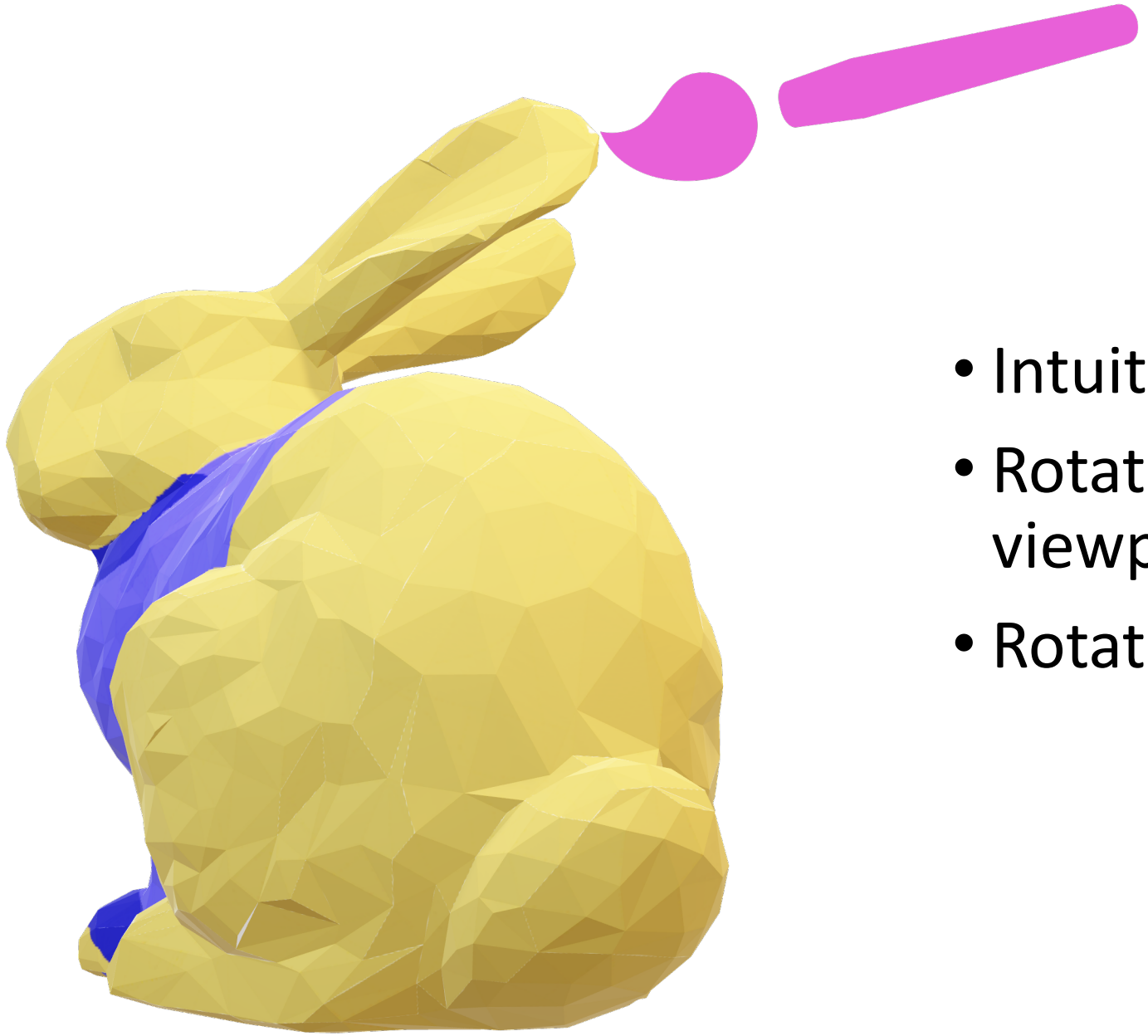

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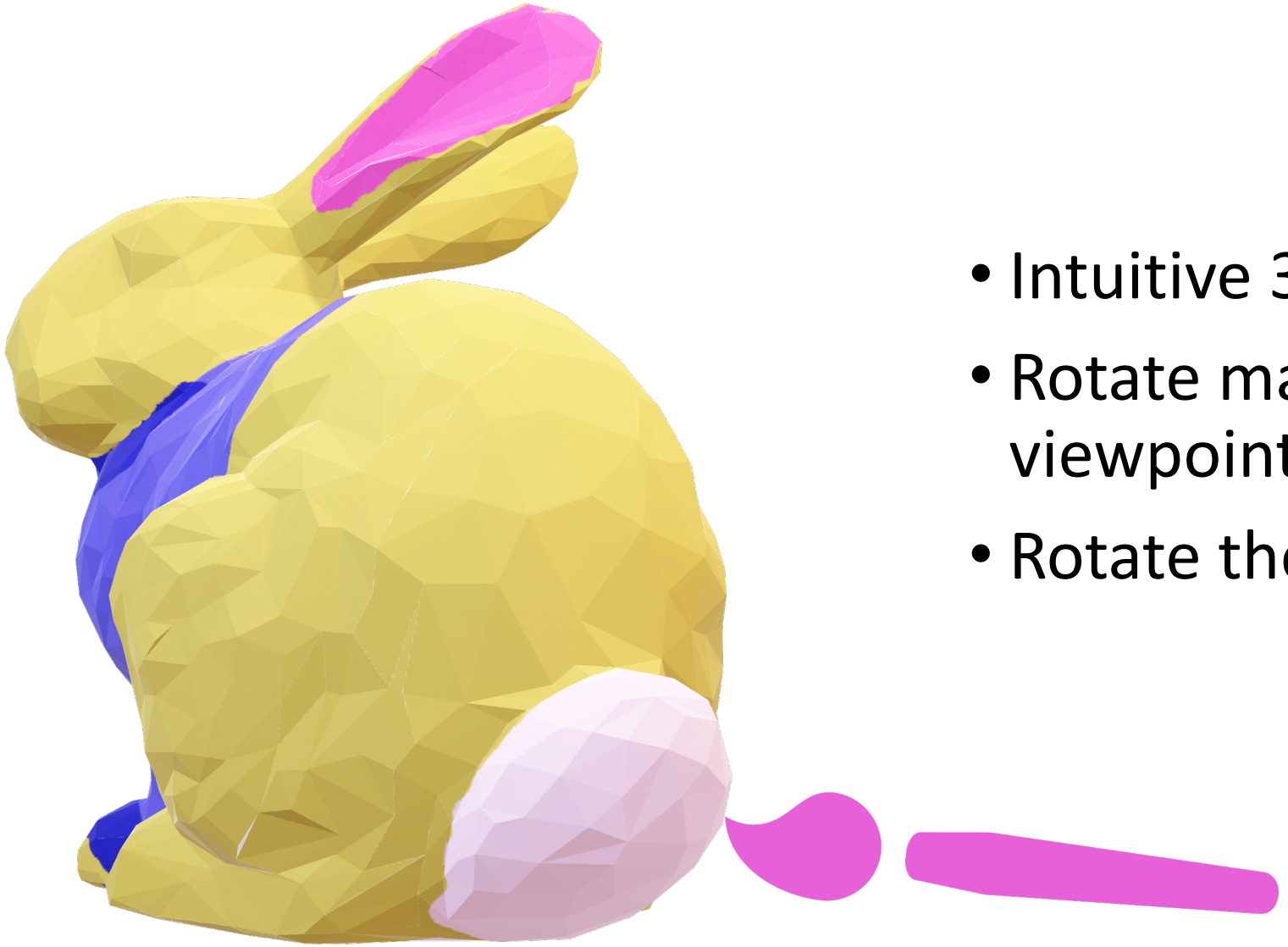

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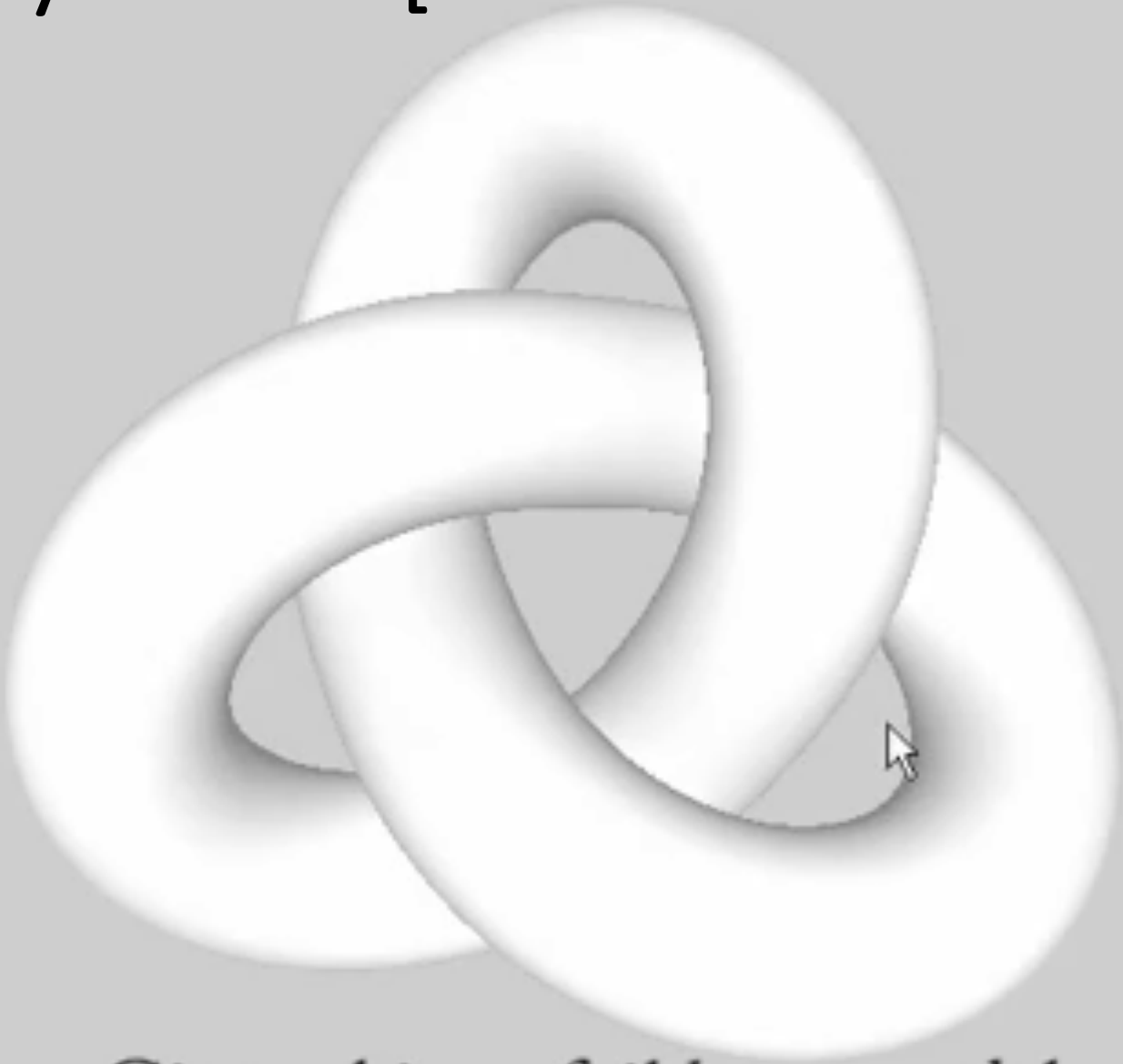
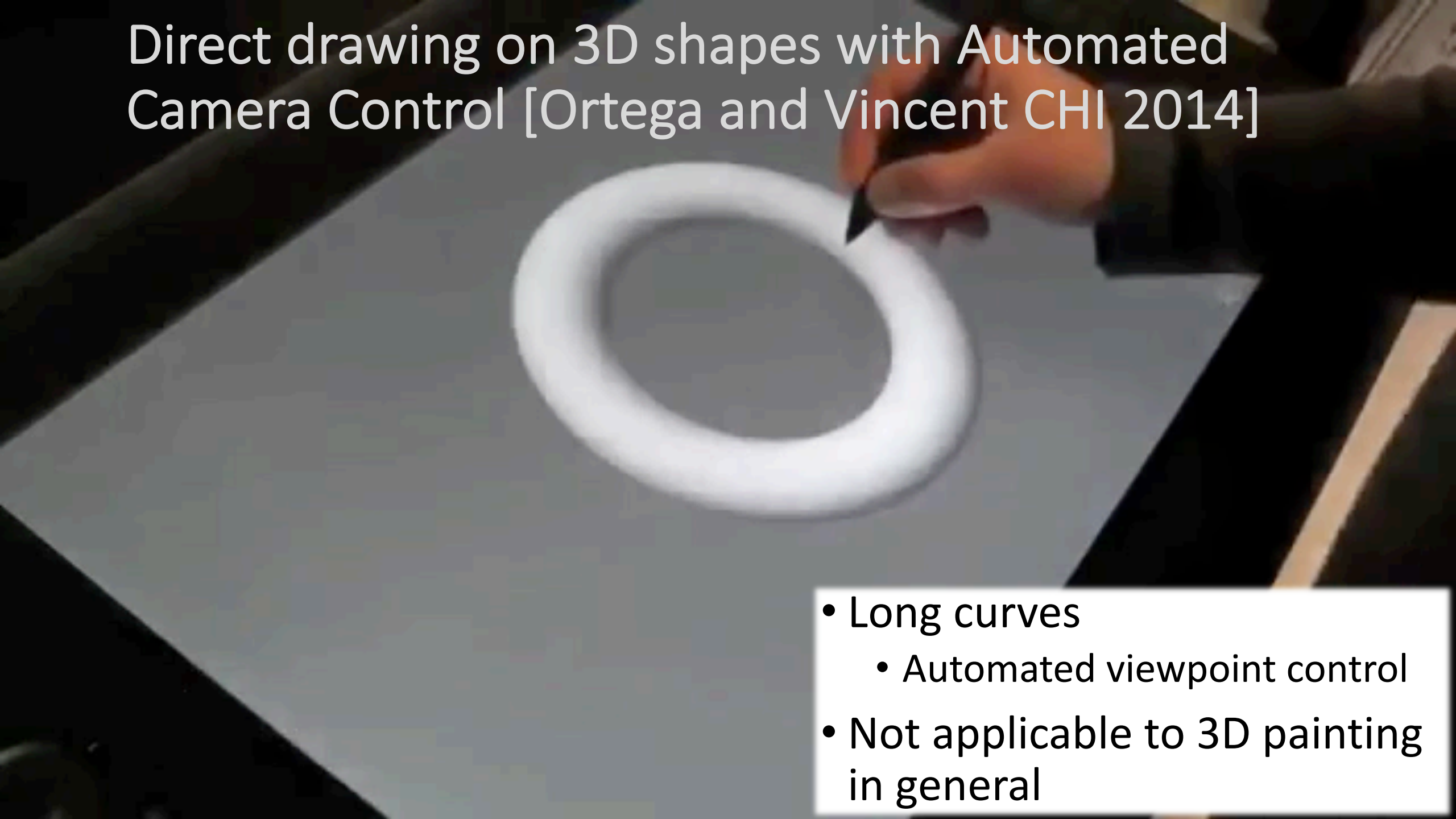
LayerPaint [Fu et al. CHI 2010]



Given this trefoil knot model

- Pop up the hidden region
  - multi-layer segmentation
- Still need to manually rotate the model

Direct drawing on 3D shapes with Automated Camera Control [Ortega and Vincent CHI 2014]



- Long curves
  - Automated viewpoint control
- Not applicable to 3D painting in general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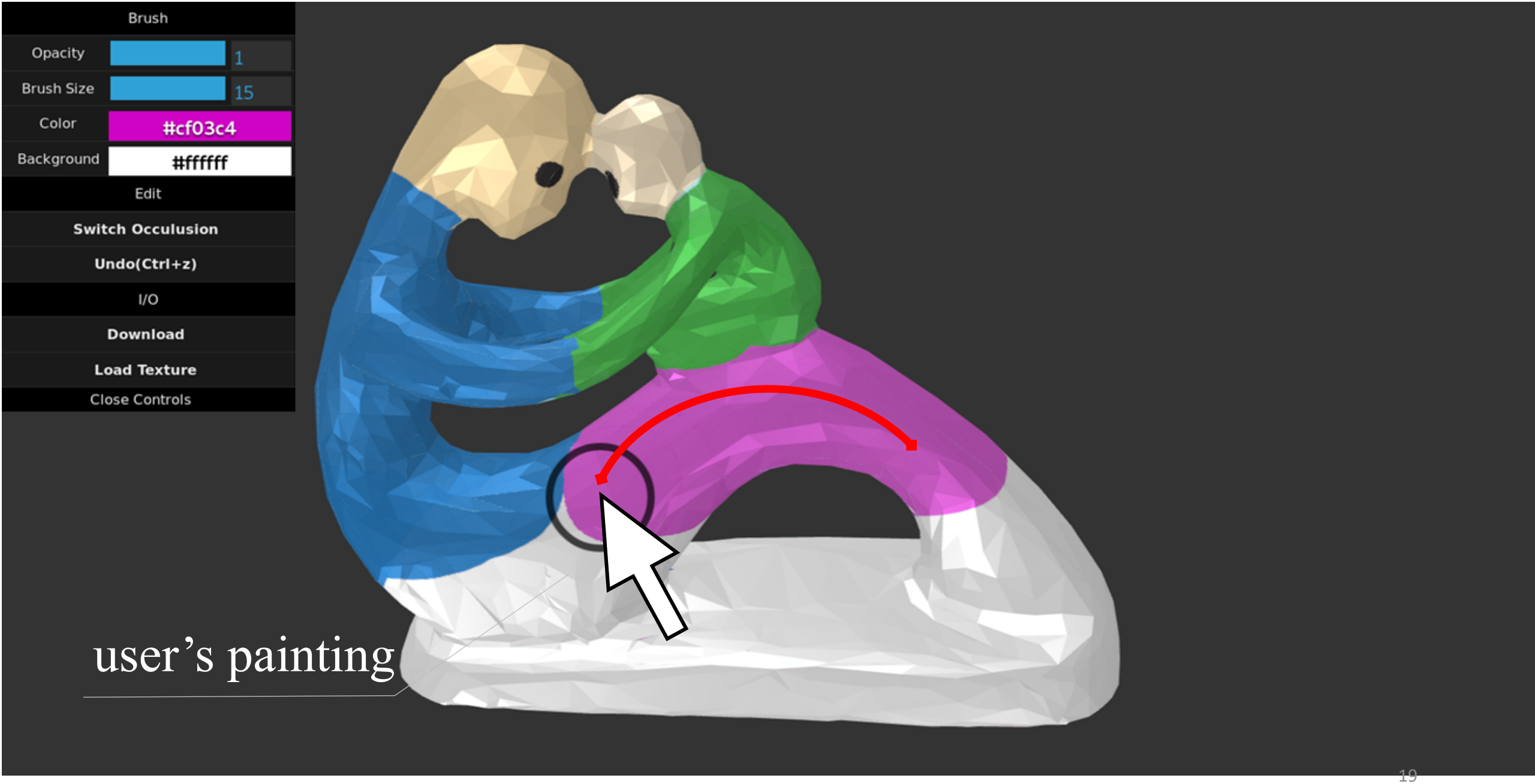
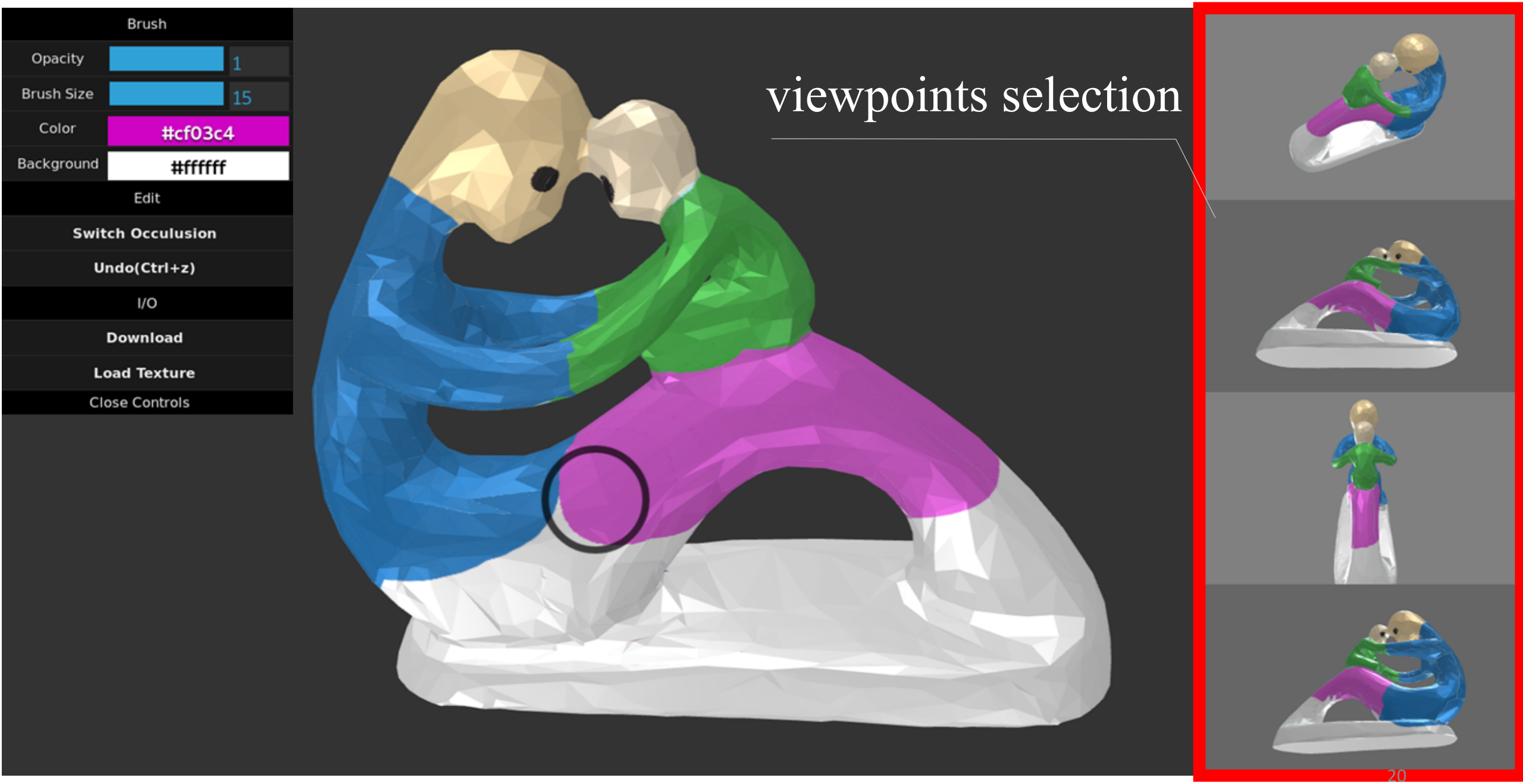
Our Method



user’s painting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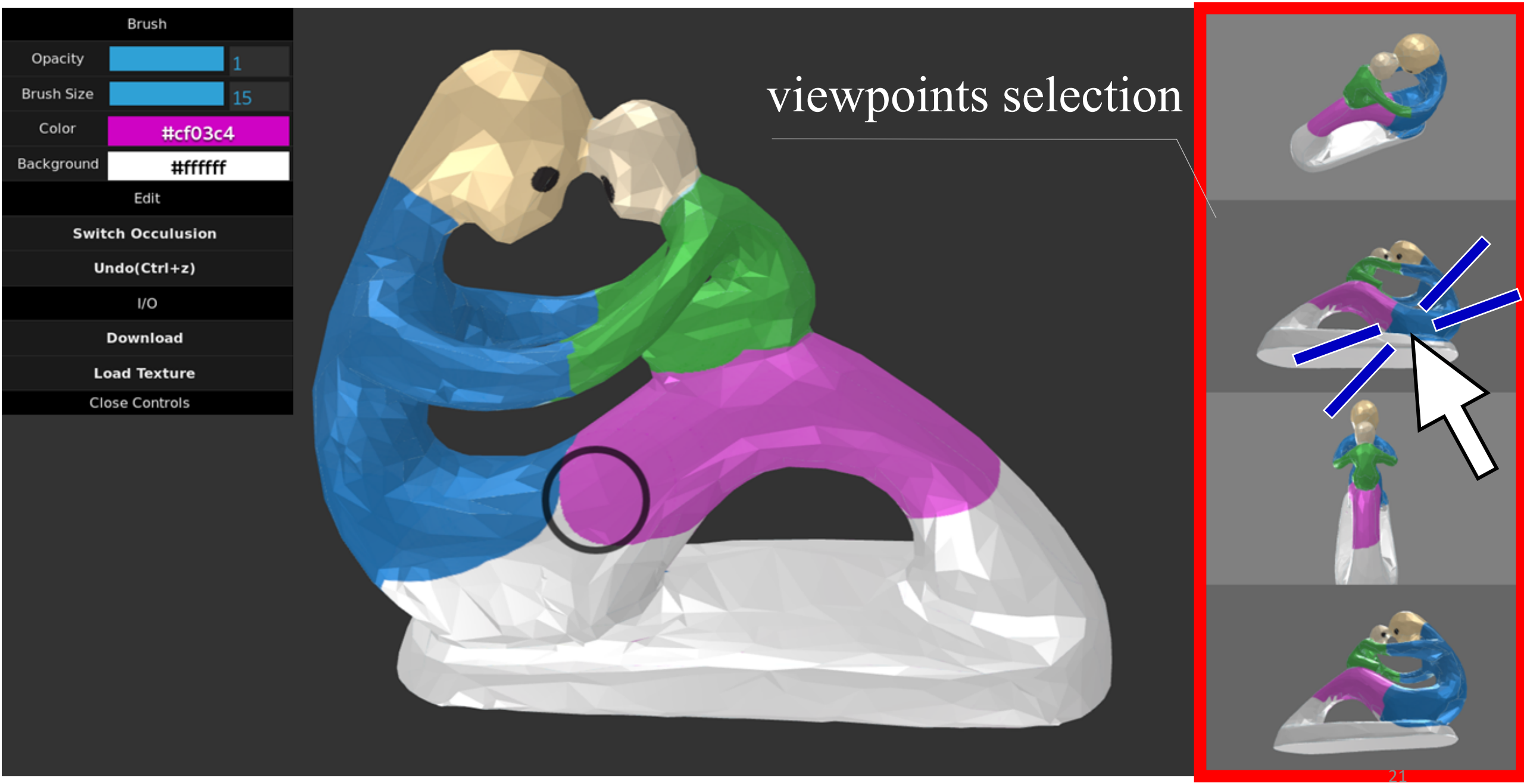
viewpoints selection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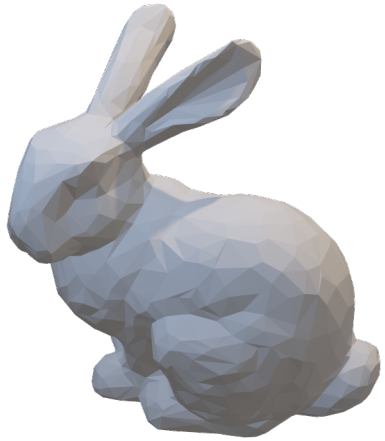
viewpoints selection

Good Viewpoint Criteria (In short)

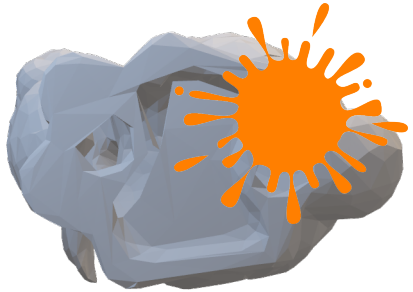
- Many front facing faces from the view
- Many unpainted region in the view

Good Viewpoint

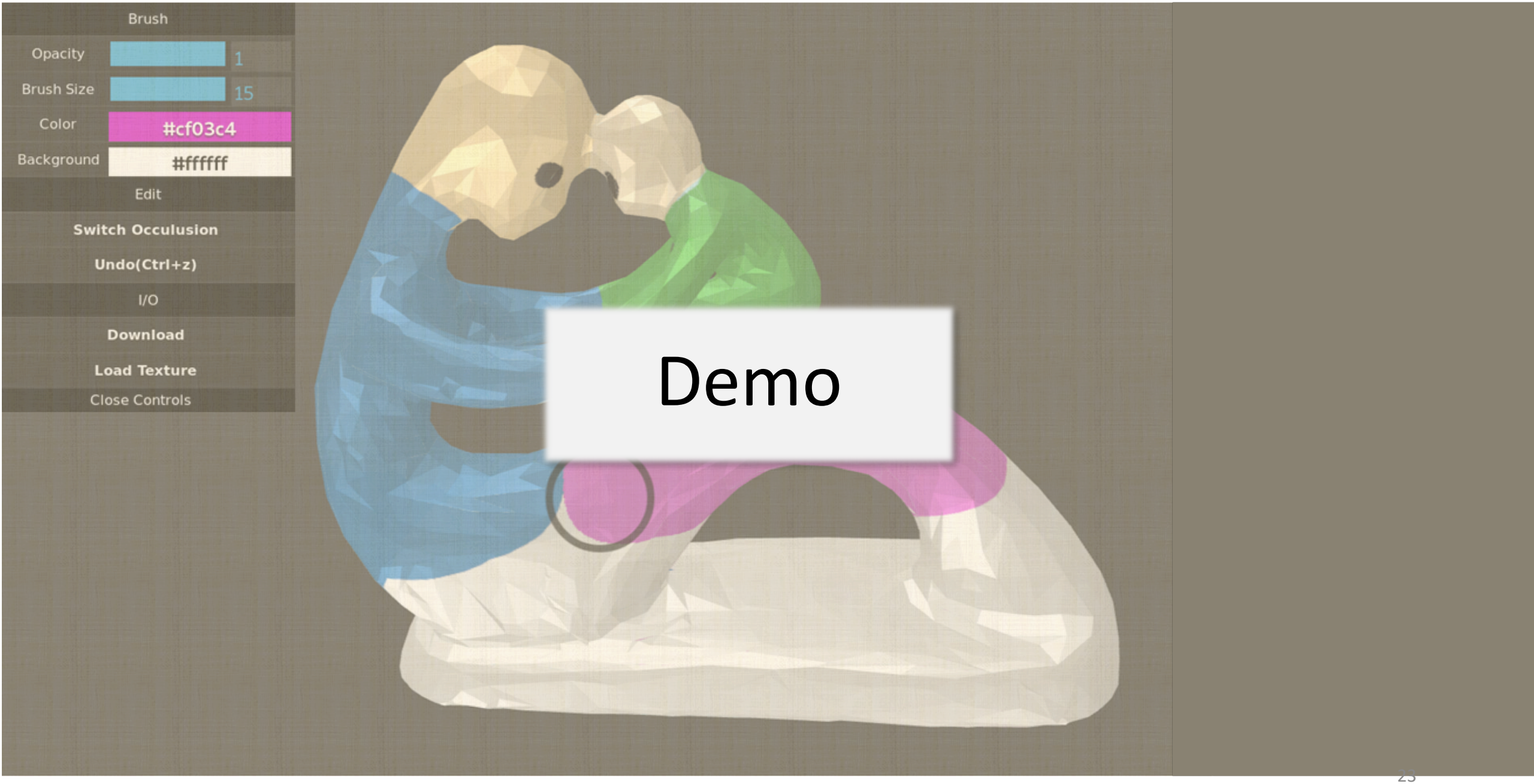


- Front facing faces
- Unpainted

Bad Viewpoint



- Few front facing faces
- Already painted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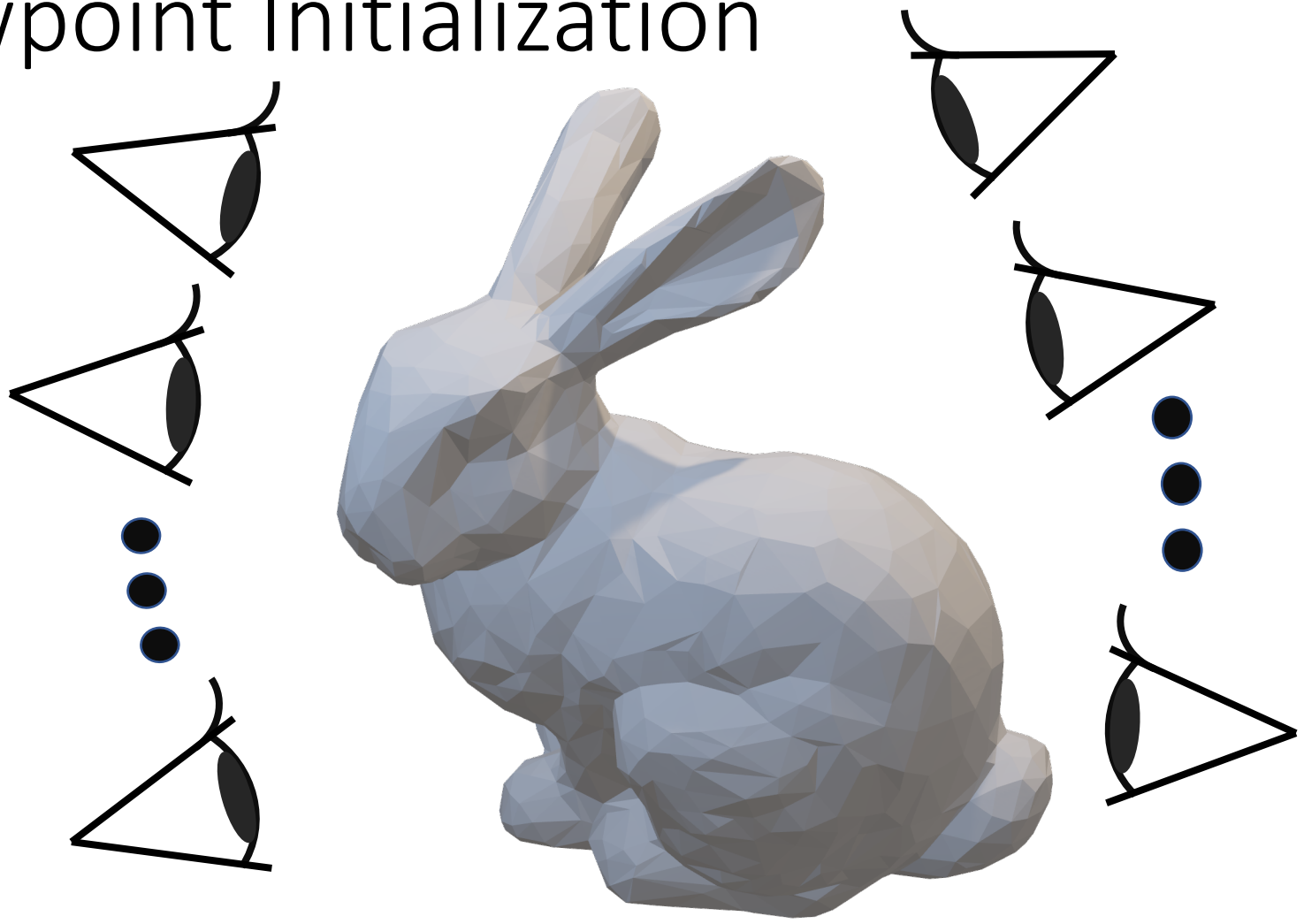
Demo

Contribution

- A novel concept to **interactively suggest optimal viewpoints** for the 3D painting task
- A simple yet effective algorithm to estimate optimal viewpoints using information from **3D geometry and a current texture**

	No manual rotation	Pop up the hidden region	Supports 3D painting in general
Fu et al.			
Ortega and Vincent			
PaintersView			

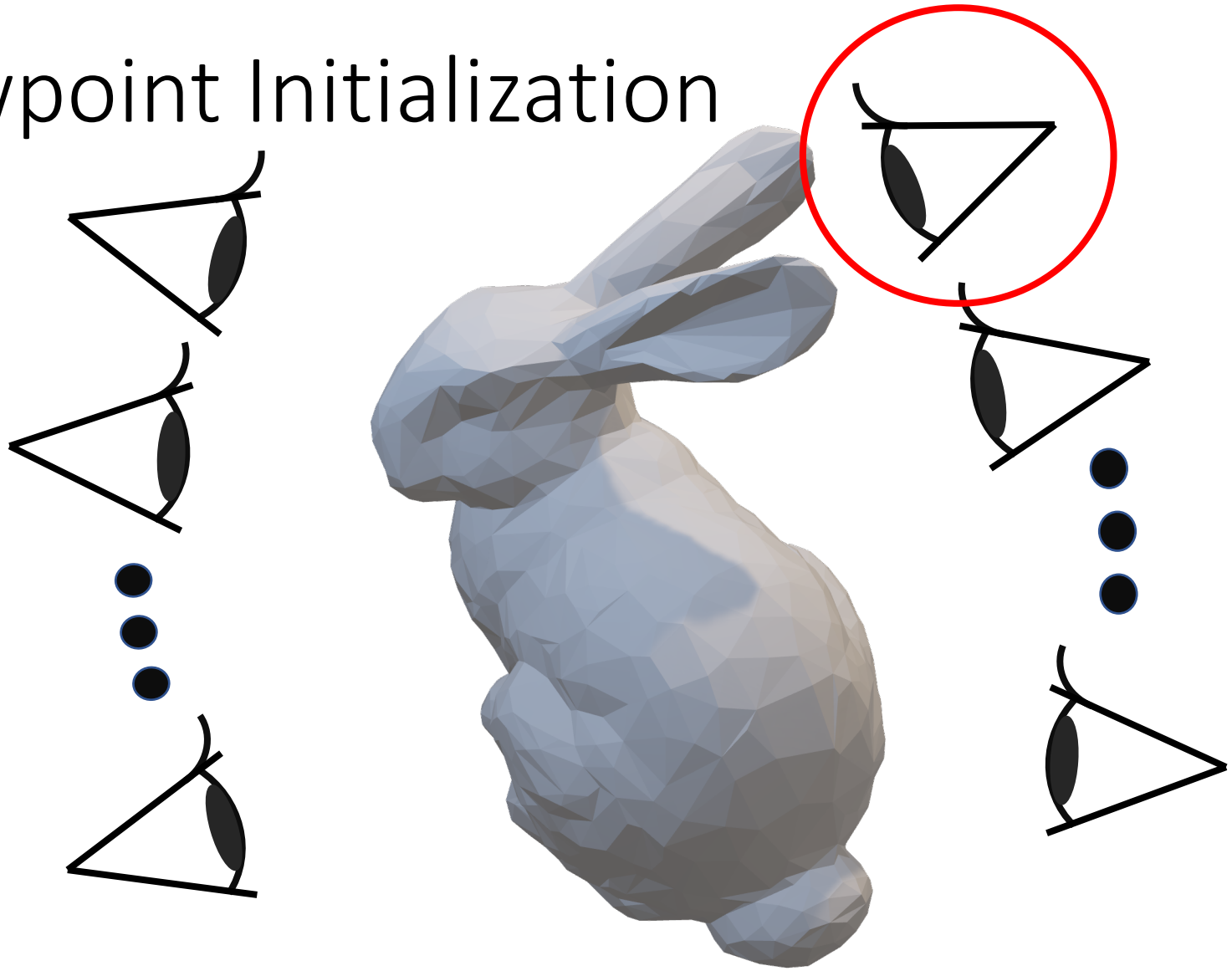
Viewpoint Initialization



N=70

Uniformly sample around the input model

Viewpoint Initialization



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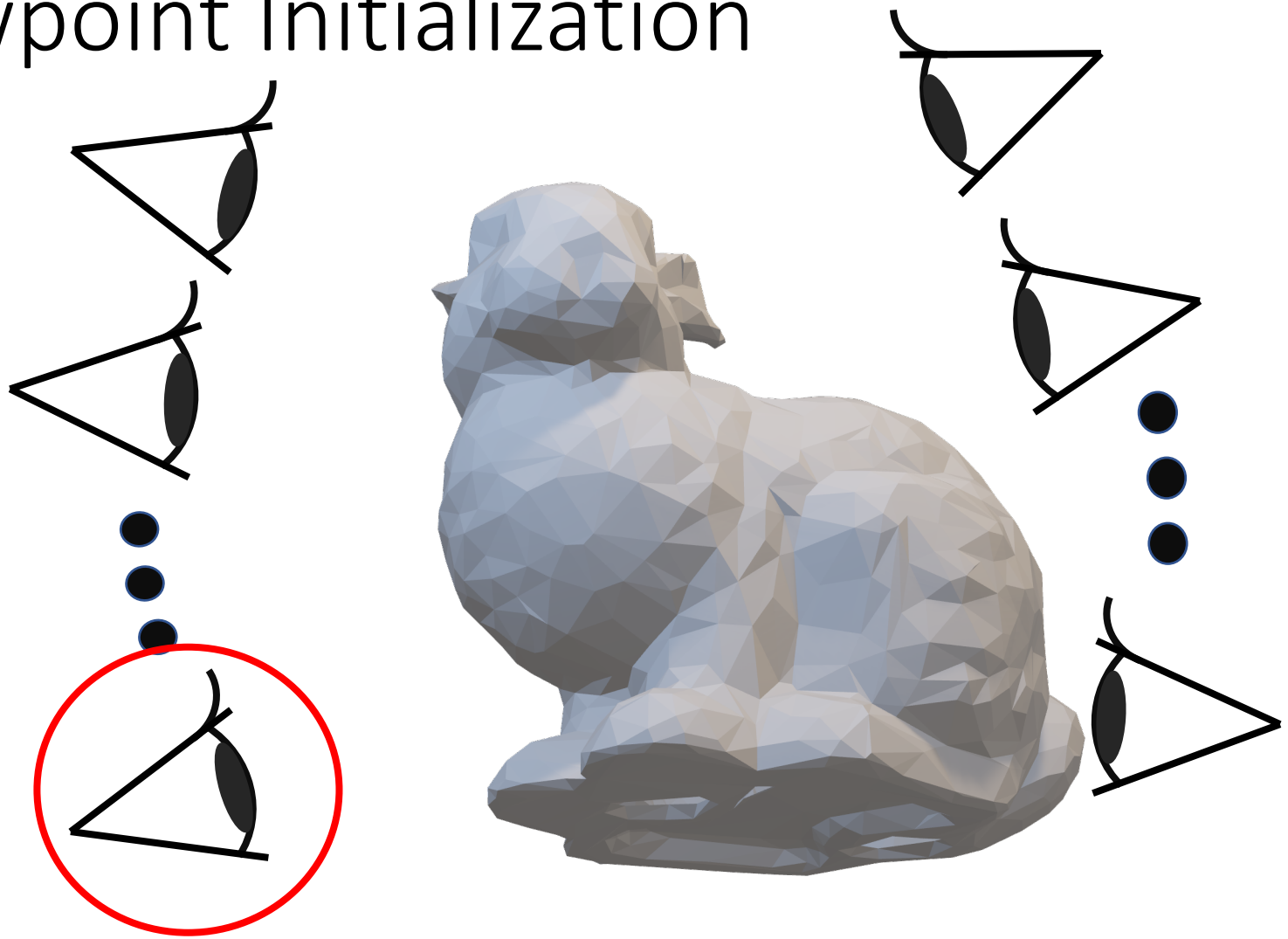

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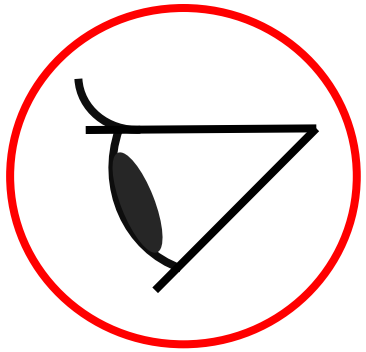
Viewpoint Function



For each viewpoints:

$$E_{geometry} + w\, E_{paint}$$

$E_{geometry}$: Geometry information
E_{paint} : Current texture painting
w = 0.04 (empirically)

Optimization Problem

$$\underset{i \in \{1, \cdots, N\}}{\arg\max}\ E_{geometry} + w\, E_{paint}$$

Optimization Problem

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From all initialized viewpoints

Optimization Problem

$$\underset{i \in \{1, \cdots, N\}}{\arg\max}\ E_{geometry} + w\, E_{paint}$$

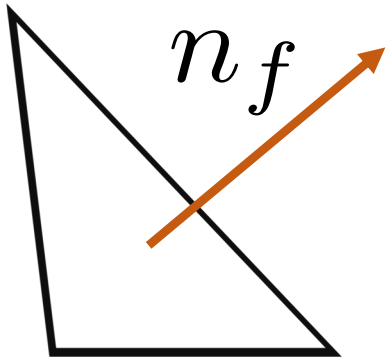
Take one which maximizes the energy function

Geometry Term

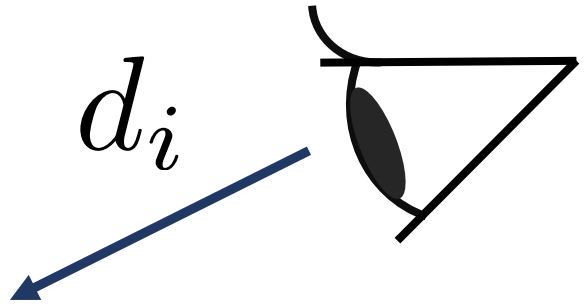
Objective: Prefer the viewpoint with more visible horizontal faces

$$E_{geometry} = \frac{1}{|F_i|} \sum_{f \in F_i} \|\vec{d_i} \cdot \vec{n}_f\|$$

F_i : Faces visible from the viewpoint



Face normal

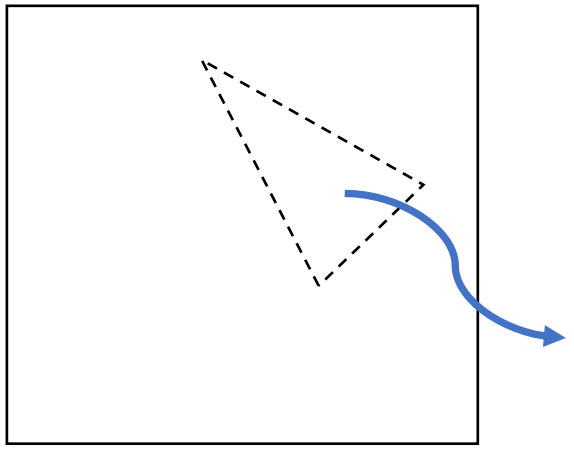


Direction vector from the viewpoint camera to the model

Current Texture Term

Objective: Prefer the viewpoint with more unpainted faces

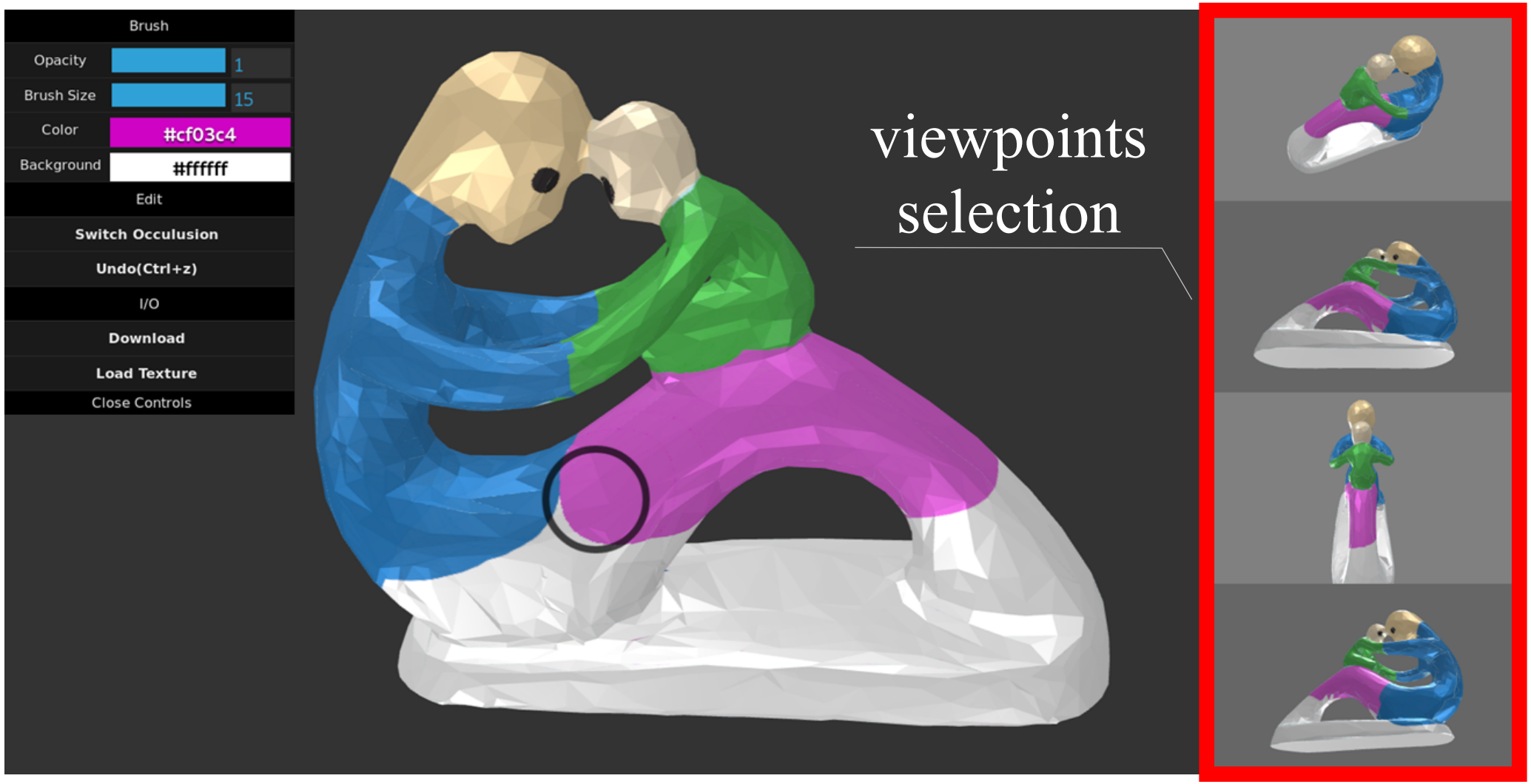
$$E_{paint} = \frac{1}{|F_i|} \sum_{f \in F_i} Upaint(f)$$



$Upaint(f)$: unpainted area of f in UV texture

UV Mapping of f

Four Viewpoint Selection



Four Viewpoint Selection

Score

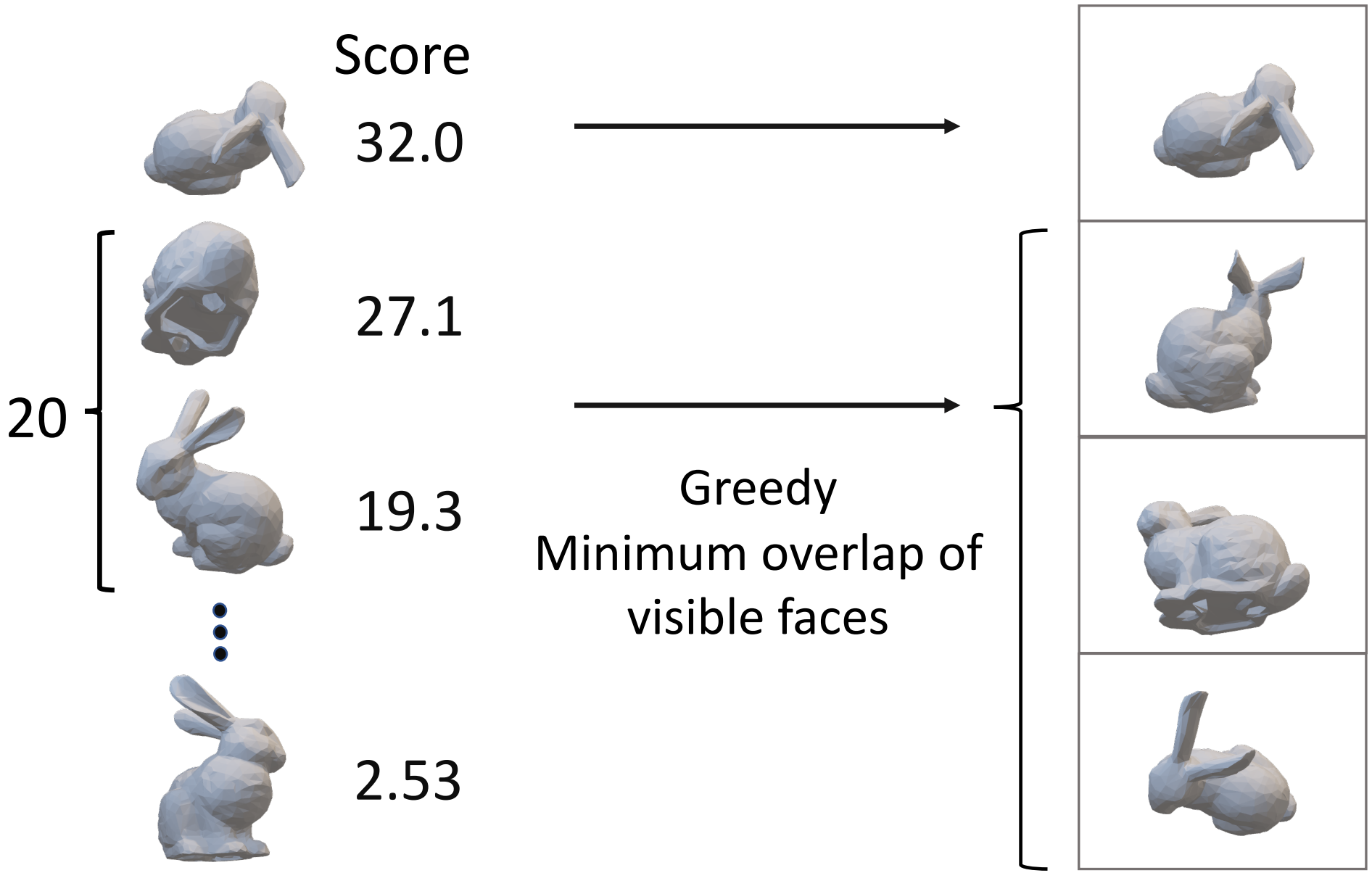
$E_{geometry} + w\, E_{paint}$ = 19.3

27.1

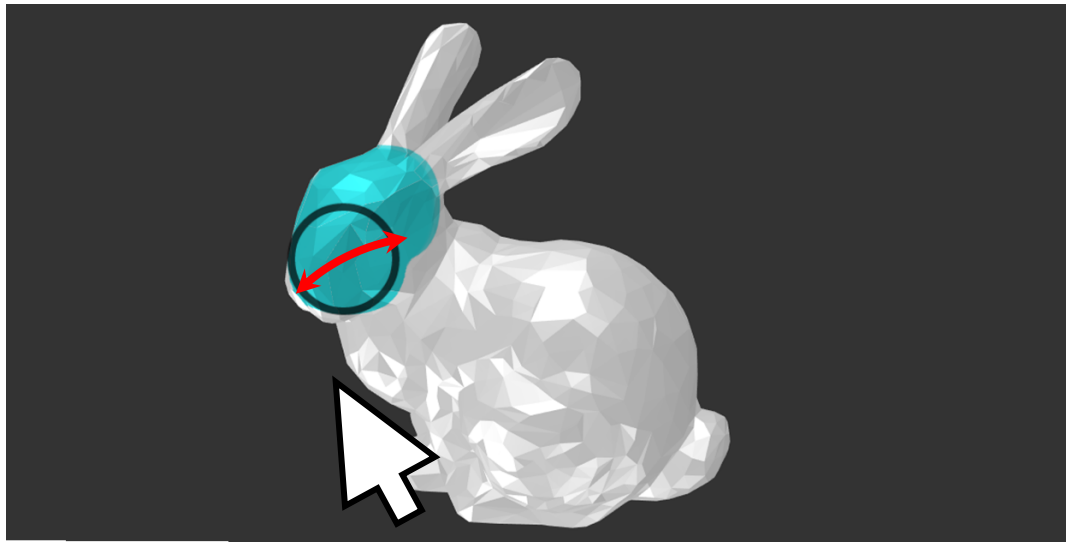
2.53

32.0

Four Viewpoint Selection

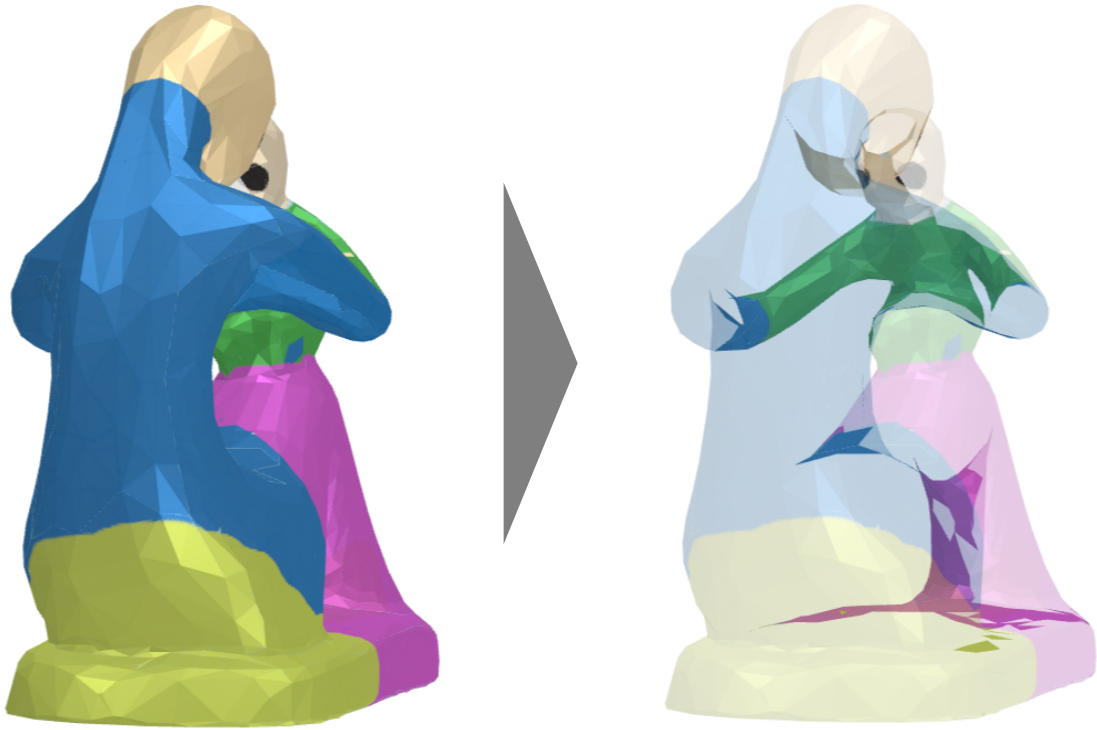


User Interaction



Annotation Tool

Limit F_i to annotated faces



Occlusion Access Tool

Users switch to make front-most faces translucent

User Study

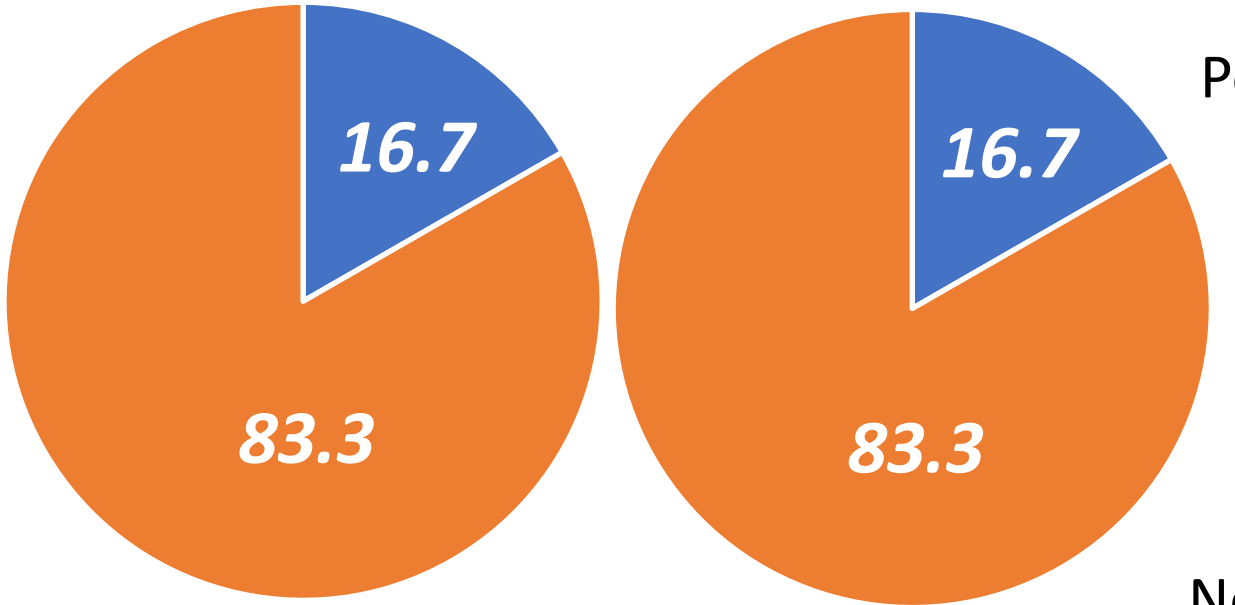
- Task1: **Manual Control vs Our Method**
- Task2: **without (w/o) Epaint term vs with (w/) Epaint term**
- 6 participants
  - Aged from 20 to 30 years old
  - Casual users who had at least one year’s experience with 3D or painting software

Task1: Manual Control vs Our Method

Example:

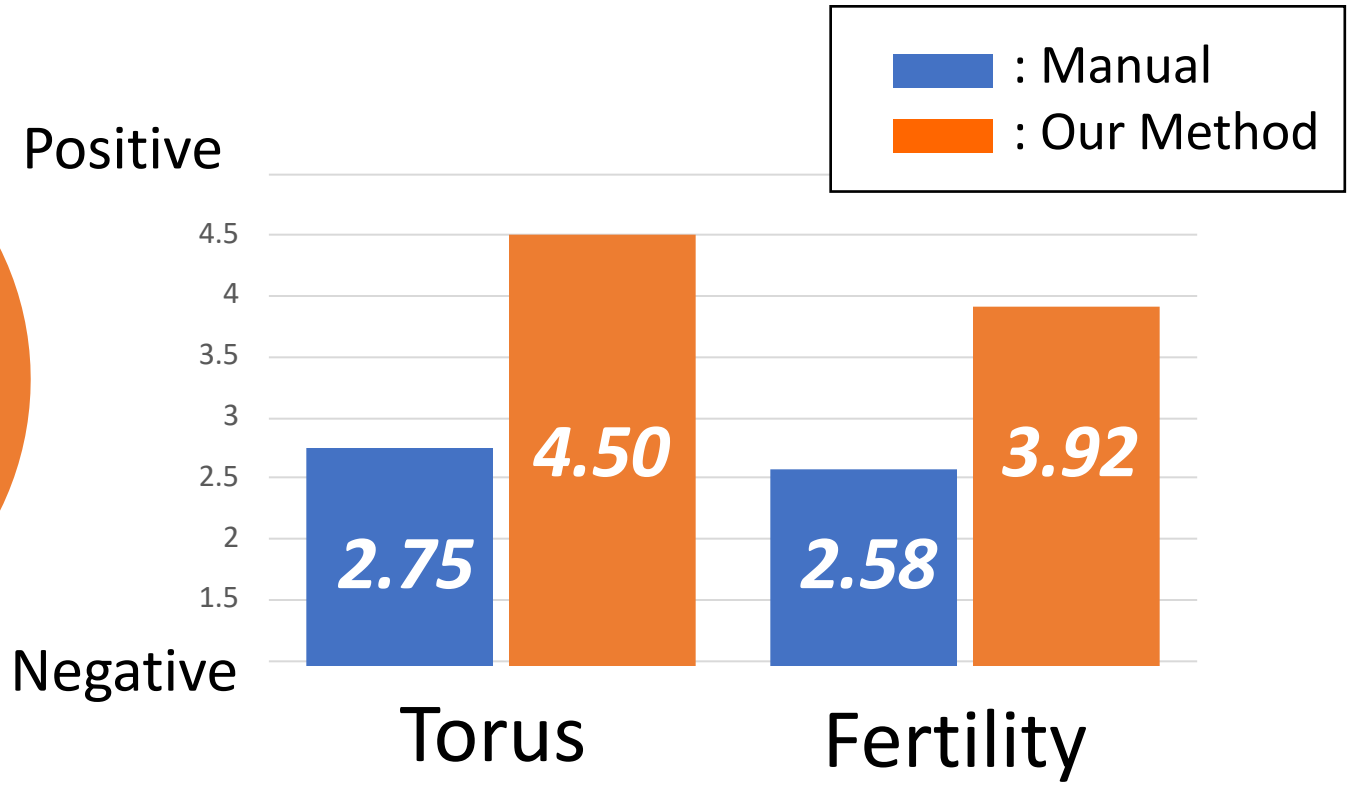
- Two unpainted models
  - A torus model and a fertility model
- Asked users to perform 3D painting, using the example as a reference

Task1: Manual Control vs Our Method



Torus Fertility

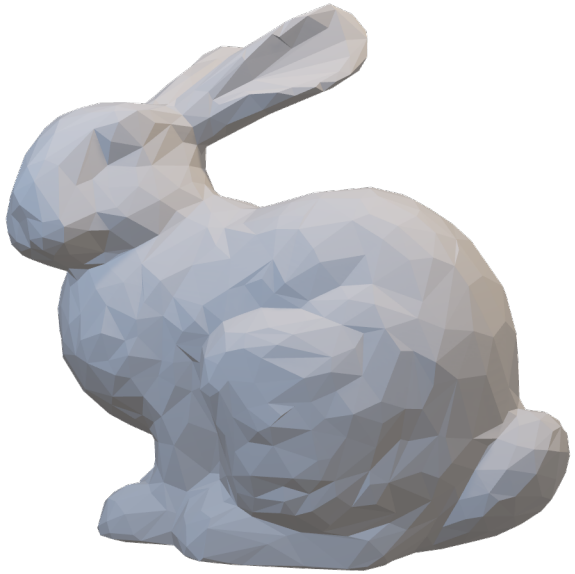
Q1: More comfortable?



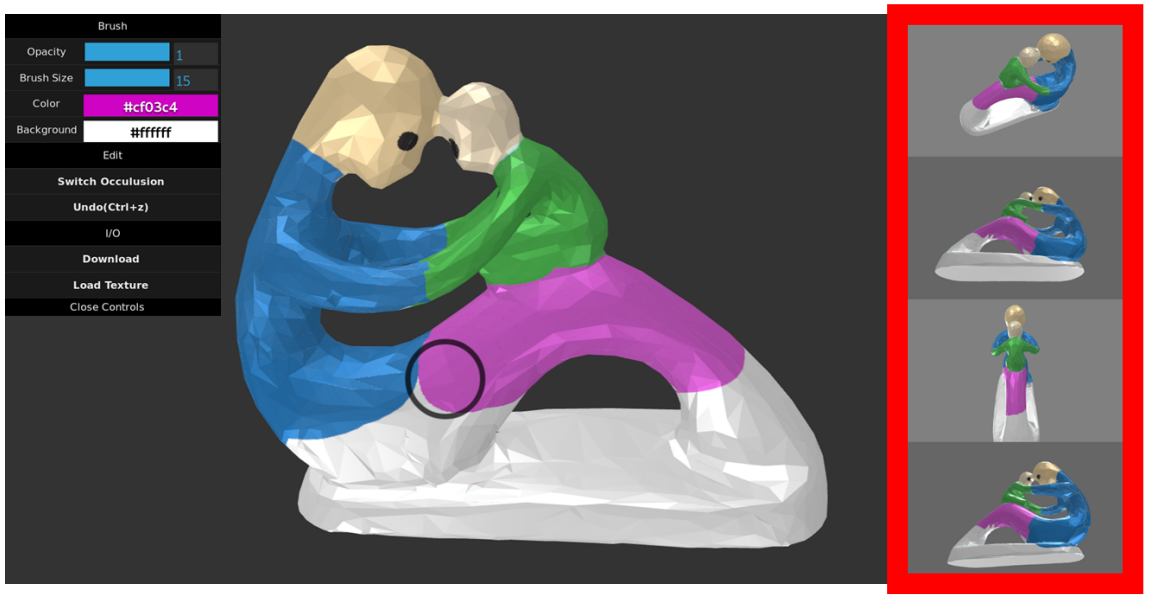
Q2: Over all usability

Task1: Manual Control vs Our Method

Average of manual control and viewpoint selection operation



Manual Control



Viewpoint Selection Operation

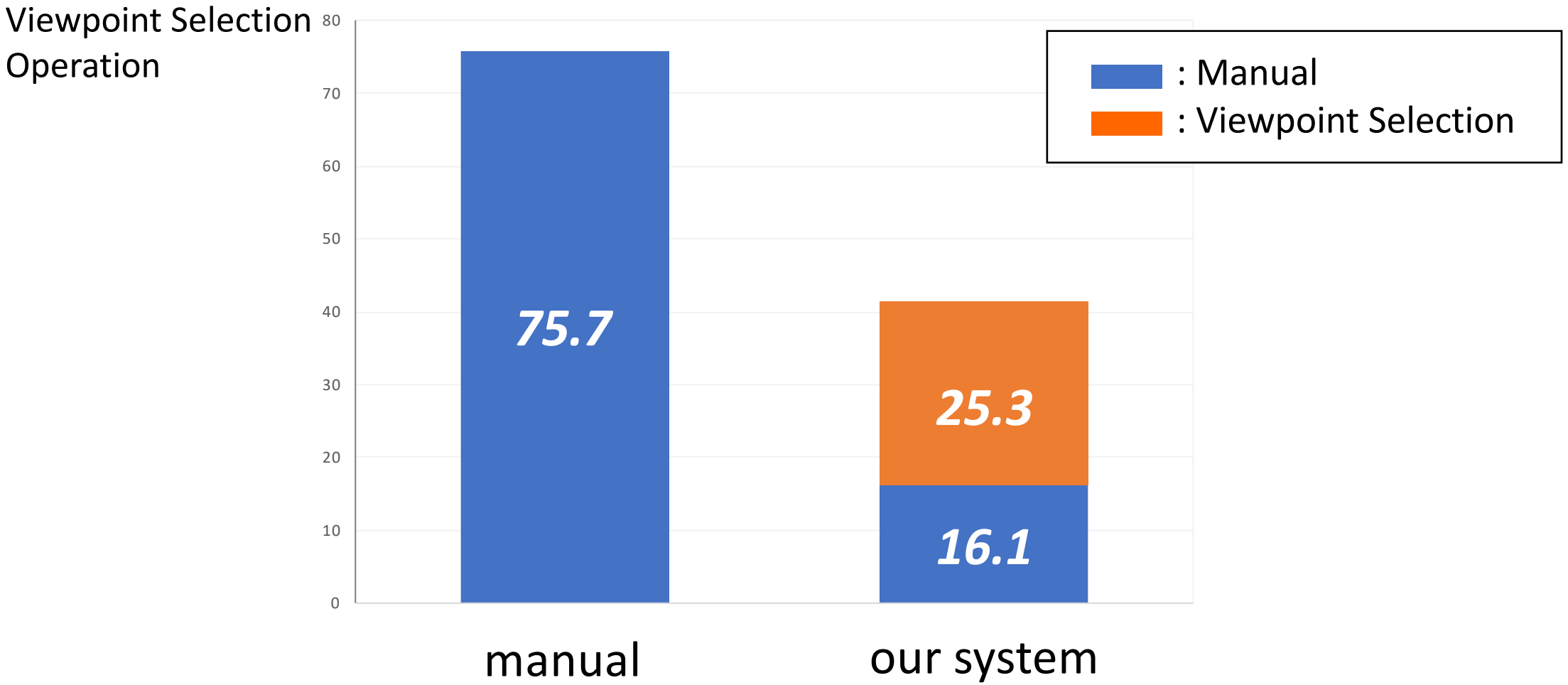
Task1: Manual Control vs Our Method

Average of manual control and viewpoint selection operation

Manual Control

Viewpoint Selection Operation

Task1: Manual Control vs Our Method



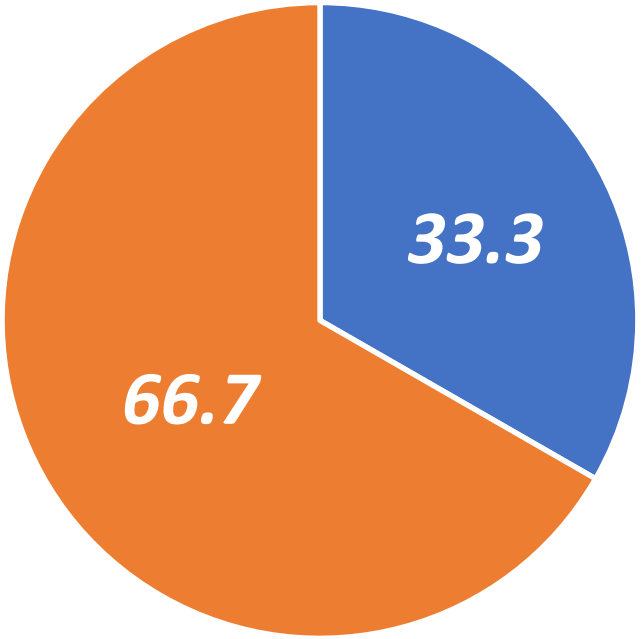
Average of manual control and viewpoint selection operation

Task2: w/o Epaint vs w/ Epaint

Example:

- One unpainted model (Bunny)
- Asked users to perform 3D painting, using the example as a reference

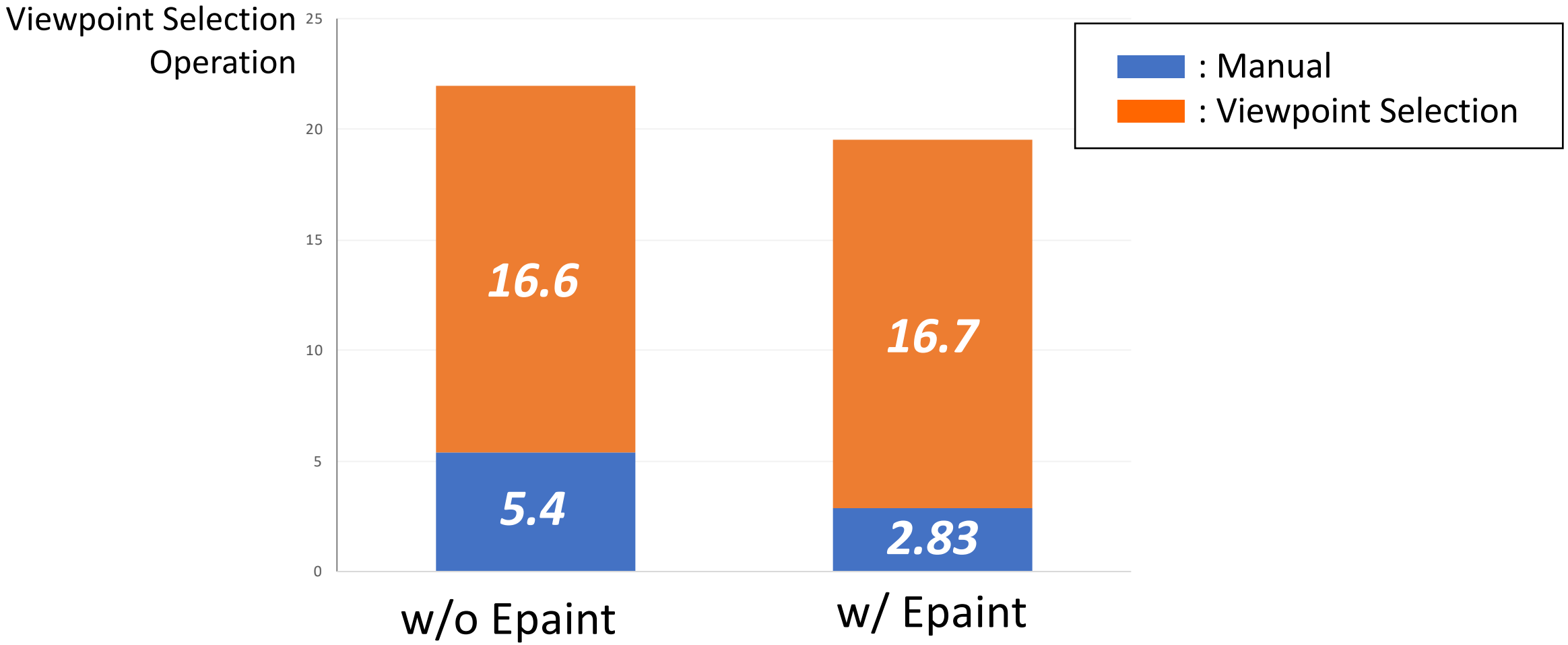
Task2: w/o Epaint vs w/ Epaint



Q1: More comfortable?

Q2: Over all usability

Task2: w/o Epaint vs w/ Epaint

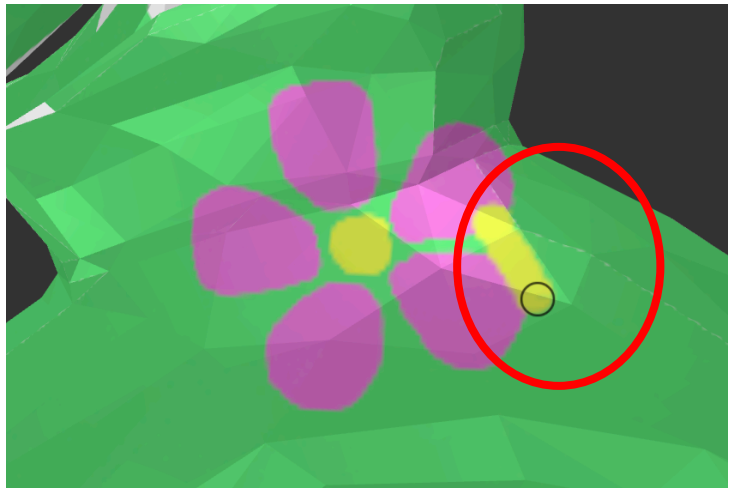


Average of manual control and viewpoint selection operation

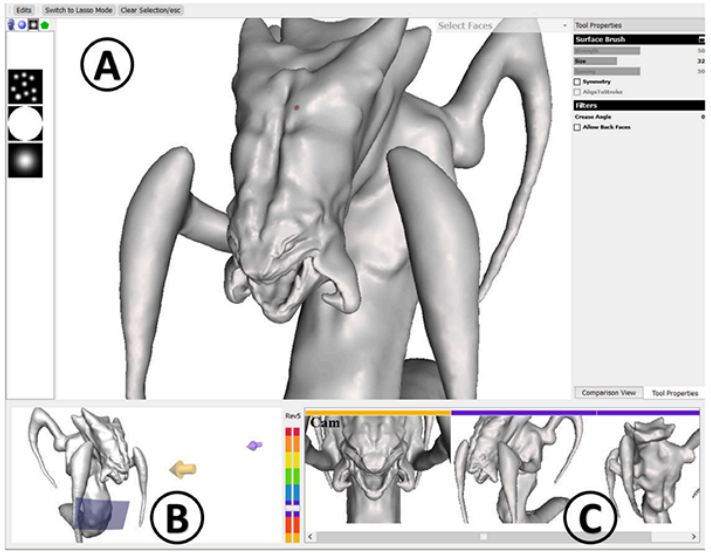
Comments (Summary)

- P1: It was **easier to interactively find best viewpoints** without slight adjustments.
- P2: The viewpoint candidates are **very useful for understanding the shape of the 3D models** and current textured results at painting time.
- P3: I wanted to **directly customize the viewpoint candidates**, for example, the opposite side of the current viewpoints.

Limitations/Future Work

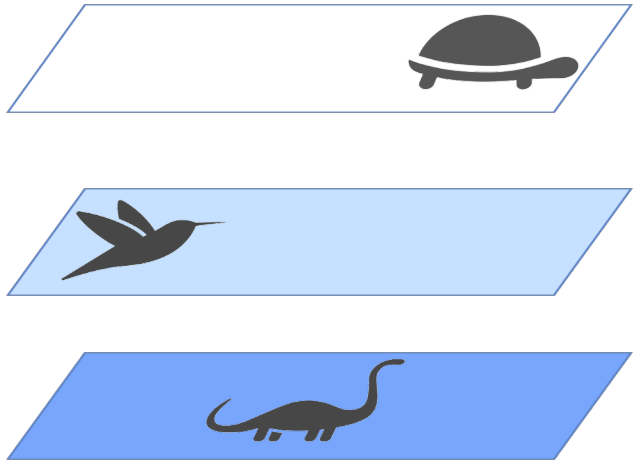


Refine when the pixel color is different from neighbors



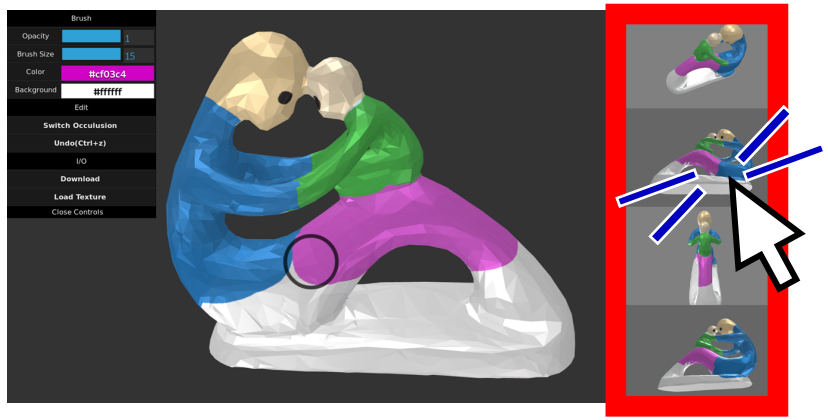
Utilize history for viewpoint suggestion

History Assisted View Authoring for 3D Models
[Chen et al. CHI 2014]



Support multi-layer texture painting

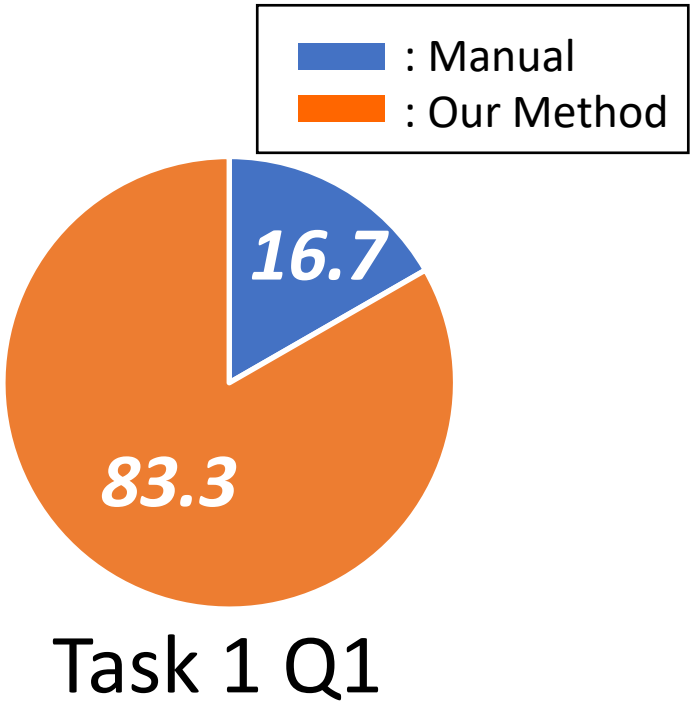
Conclusion



Find the next viewpoints for drawing on the unpainted areas

$$\arg\max_{i \in \{1,\cdots,N\}} E_{geometry} + w\, E_{paint}$$

Optimization function using geometry and intermediate paint results

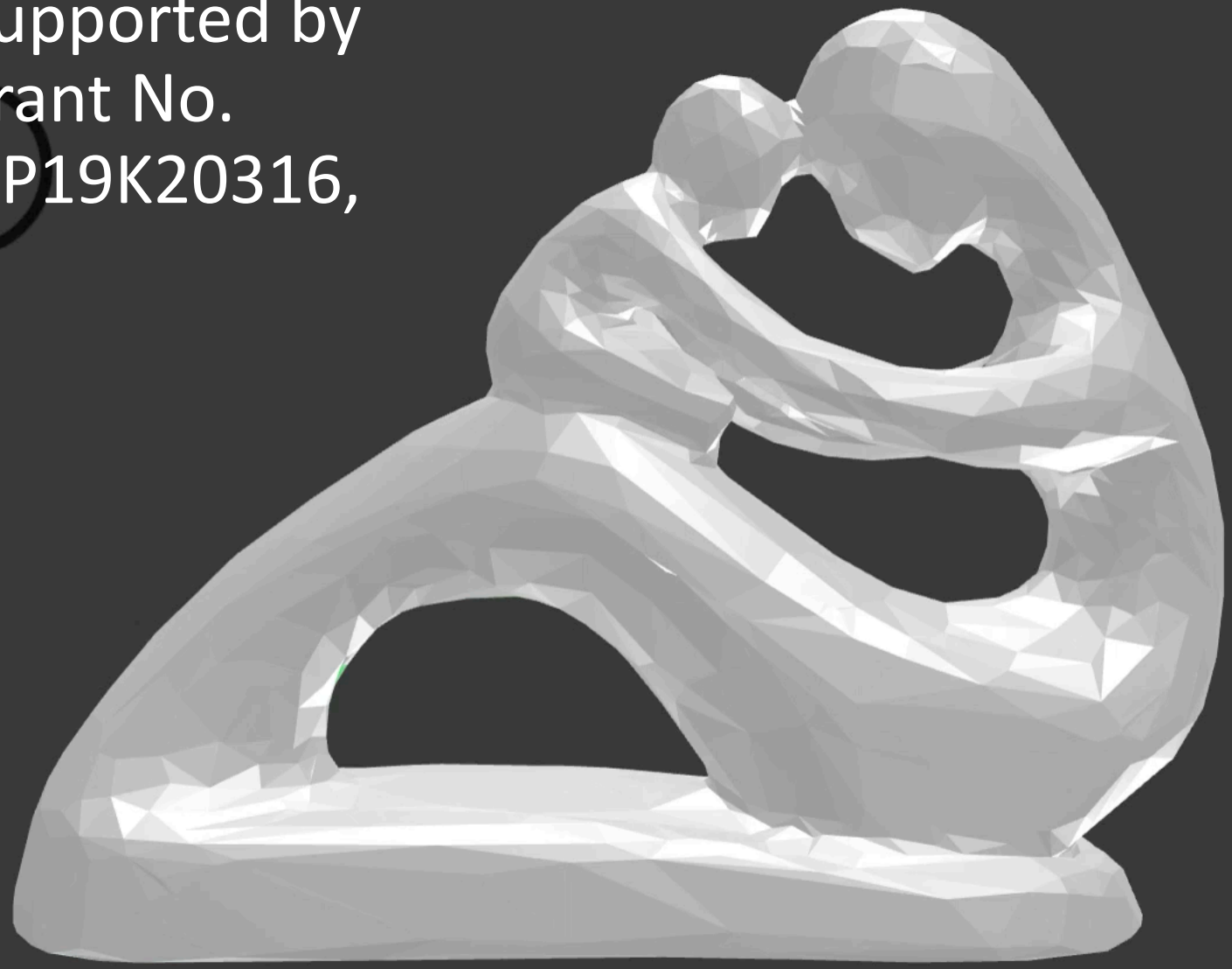


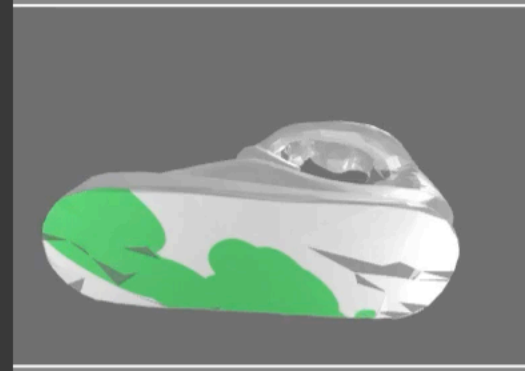
Task 1 Q1

The proposed system was rated higher on average by user study

Acknowledge

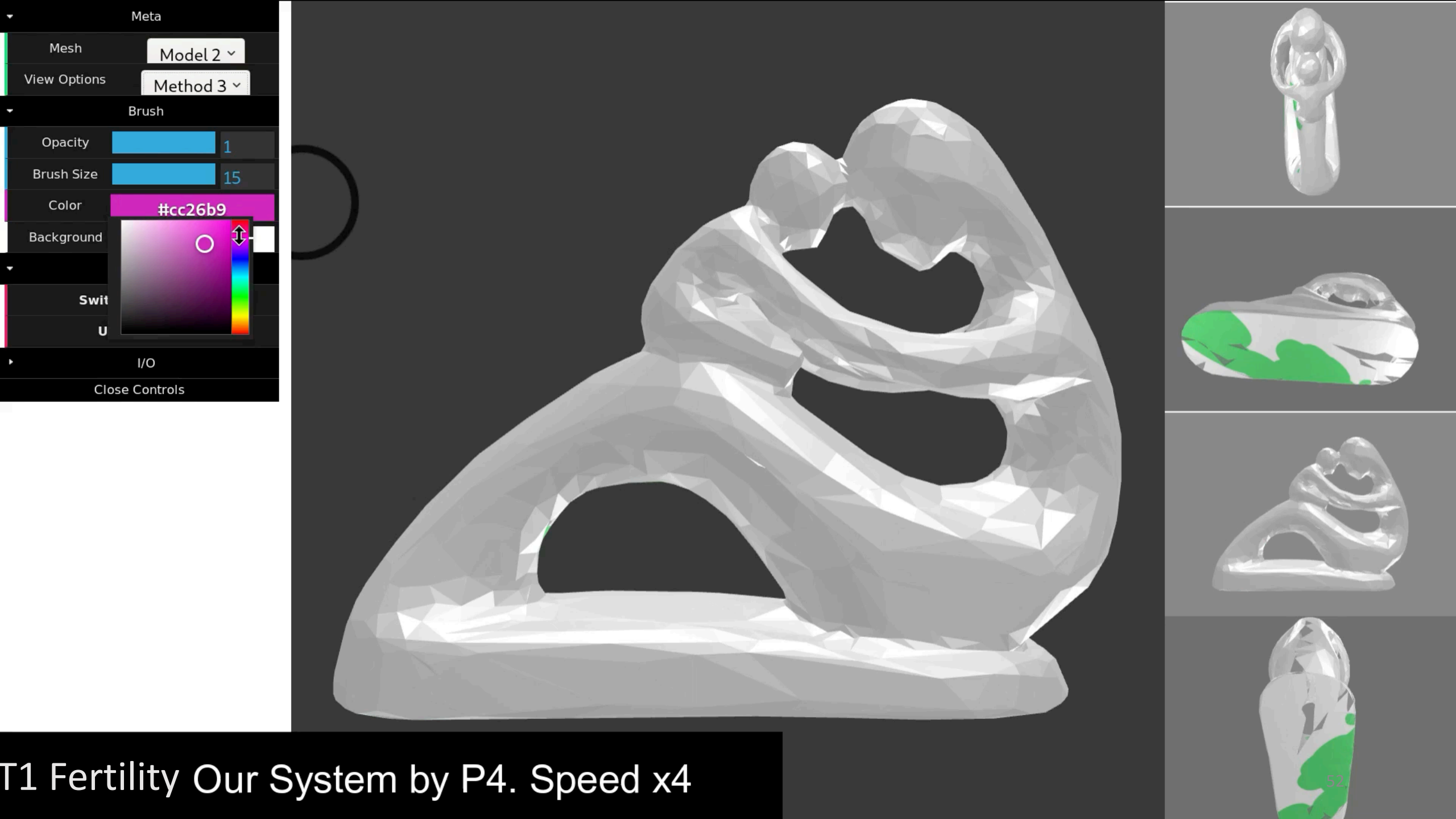
This work was supported by JSPS KAKENHI grant No. JP17H00752 & JP19K20316, Japan.





T1 Fertility Our System by P4. Speed x4

Backup Slides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T1 Fertility Our System by P4. Speed x4
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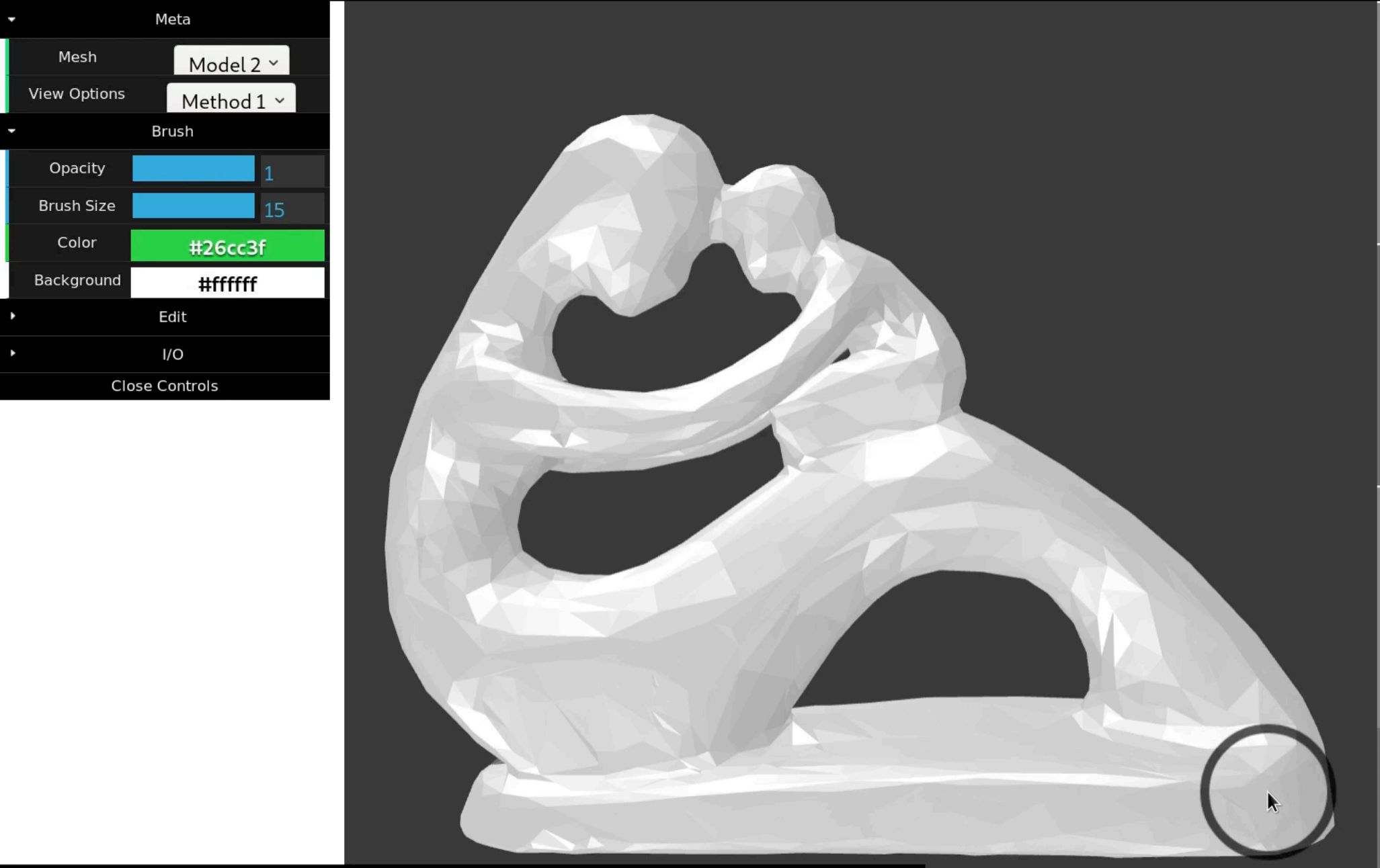

T1 Fertility Manual by P4. Speed x4