UC San Diego

Meta

Transforming Unstructured Hair Strands into Procedural Hair Grooms

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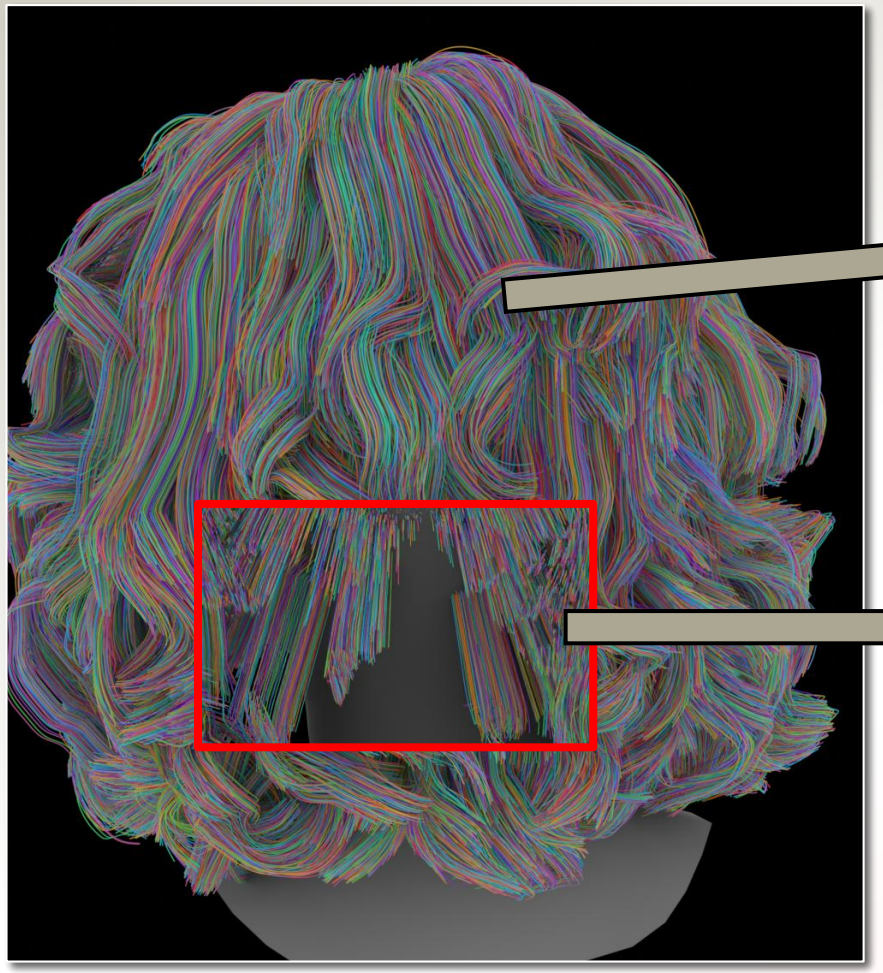
Hair Reconstruction

Video

3D Hair Strands

Hair Reconstruction



3D Hair Strands

100k unstructured strands

Difficult to edit!

Poor inner hair structure

Difficult to simulate!

Procedural Editing

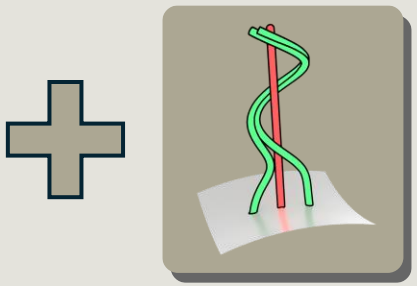
Artist-designed Procedural Grooms

Hard to Edit

Easy to Edit, Guaranteed Structure

Unstructured Strands

Guide Strands

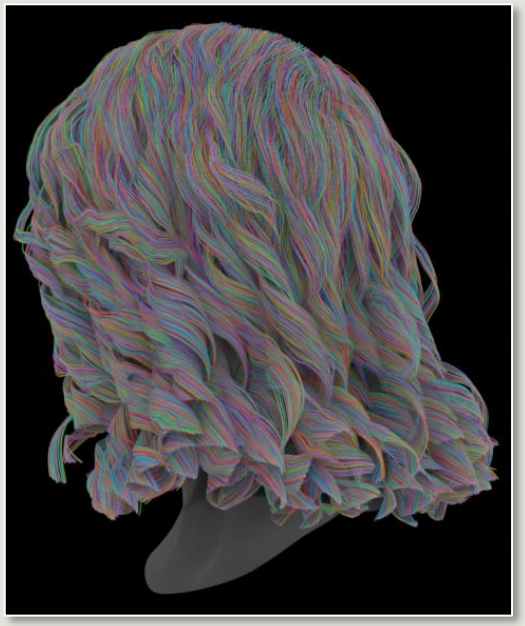


Procedural Operators

Procedural Groom

Our Paper: Unstructured Strands to Procedural Grooms

Input

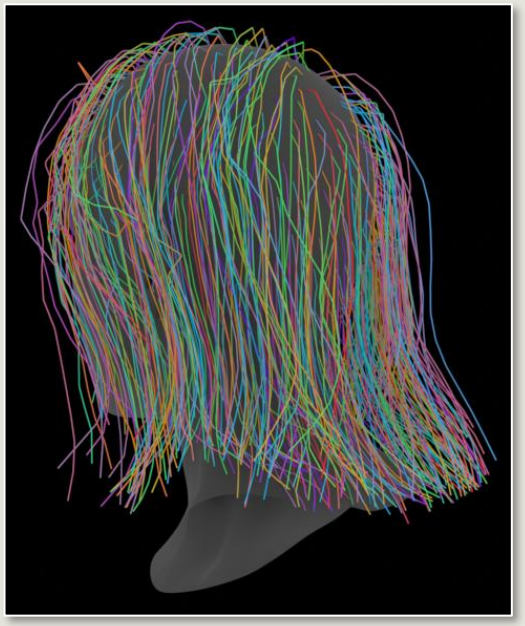


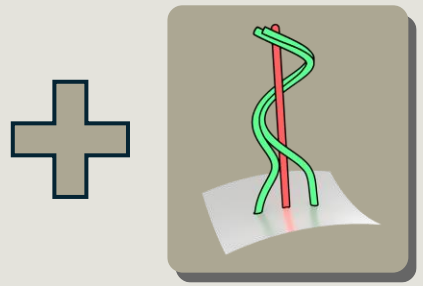
Unstructured Strands

No training data needed!

Optimization

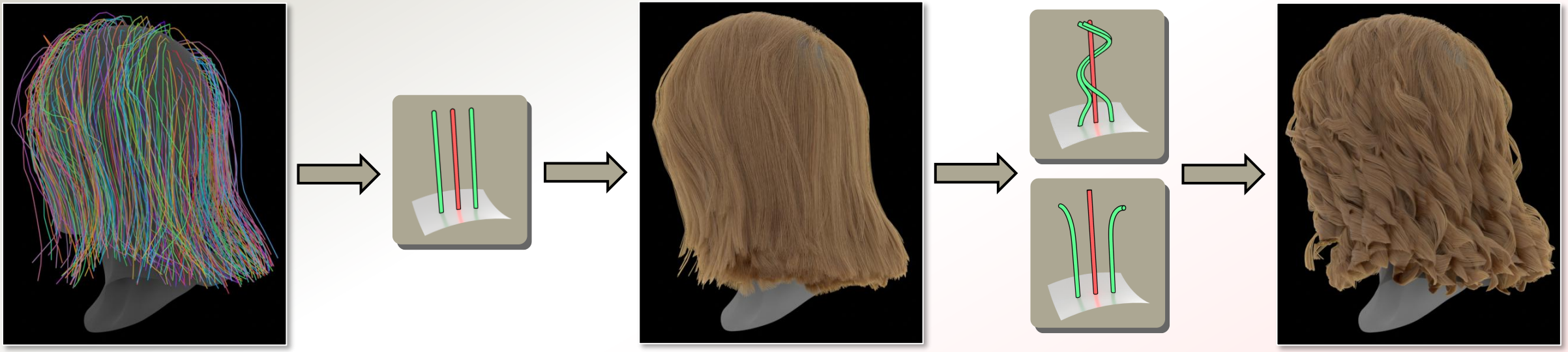
Outputs





Procedural Groom

Our Procedural Grooming Pipeline



Guide Strands

Instancing

Instanced Strands

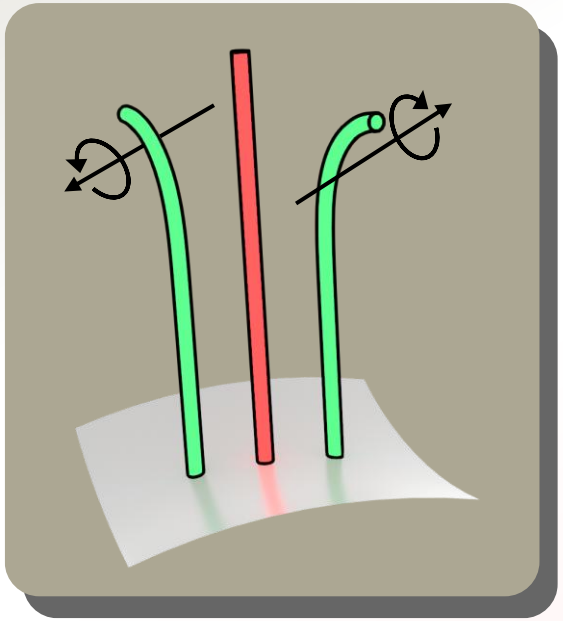
Procedural Operators

Procedural Groom

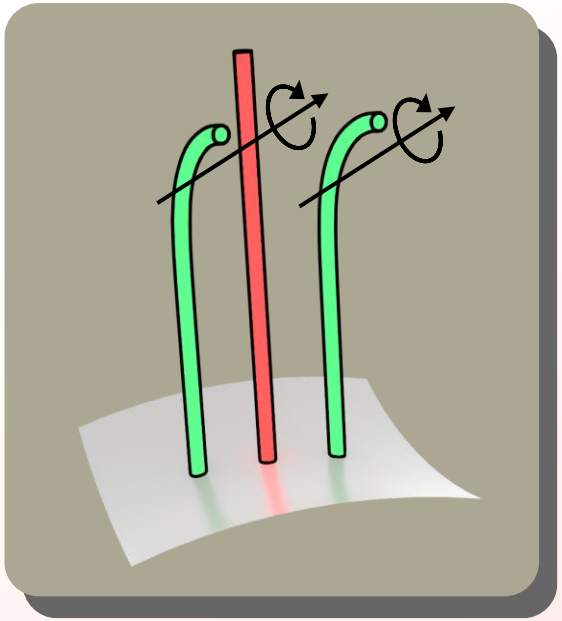
Operators Apply Random Variations to Different Strands

Guide Strand
Instanced Strand

Bend:
θ degrees
around axis v

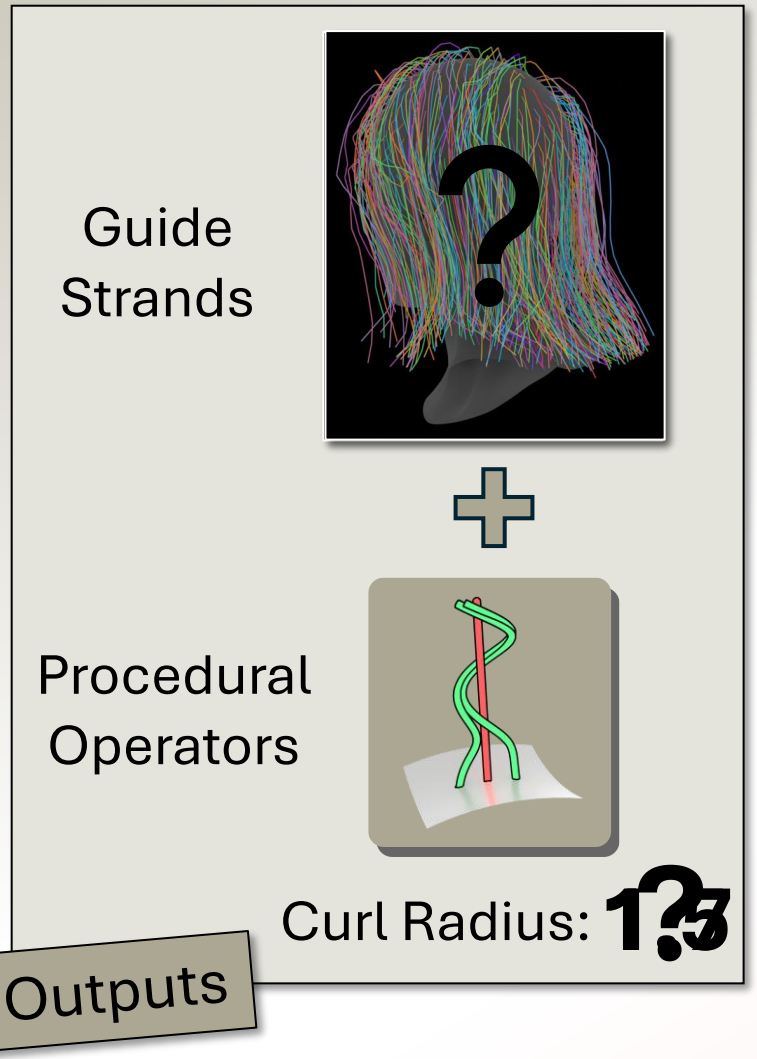


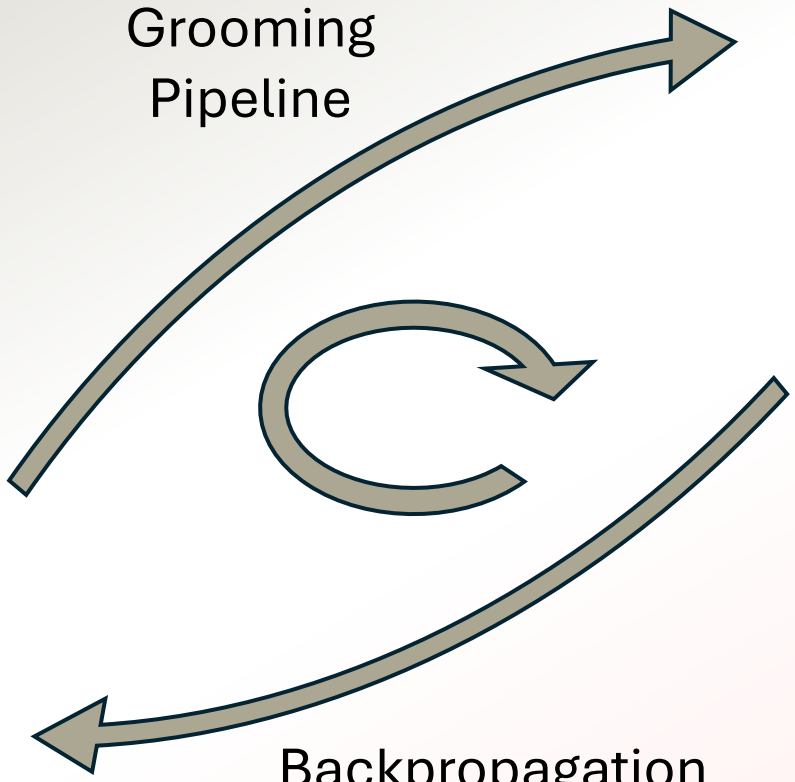
✓ With Random Axis Variation

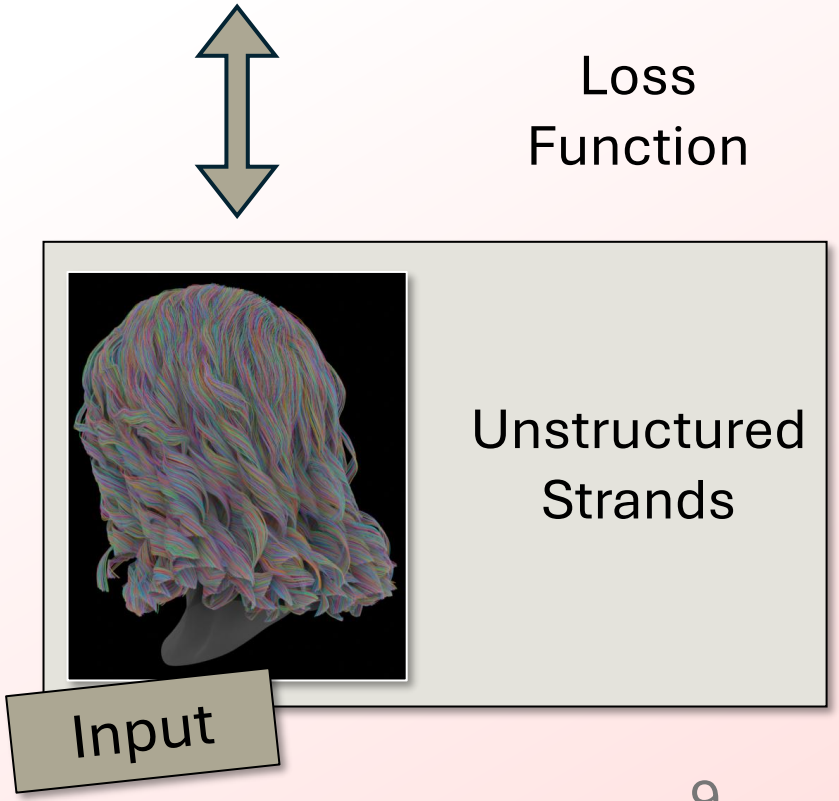


✗ Without Random Axis Variation

Optimization Task







Loss Function

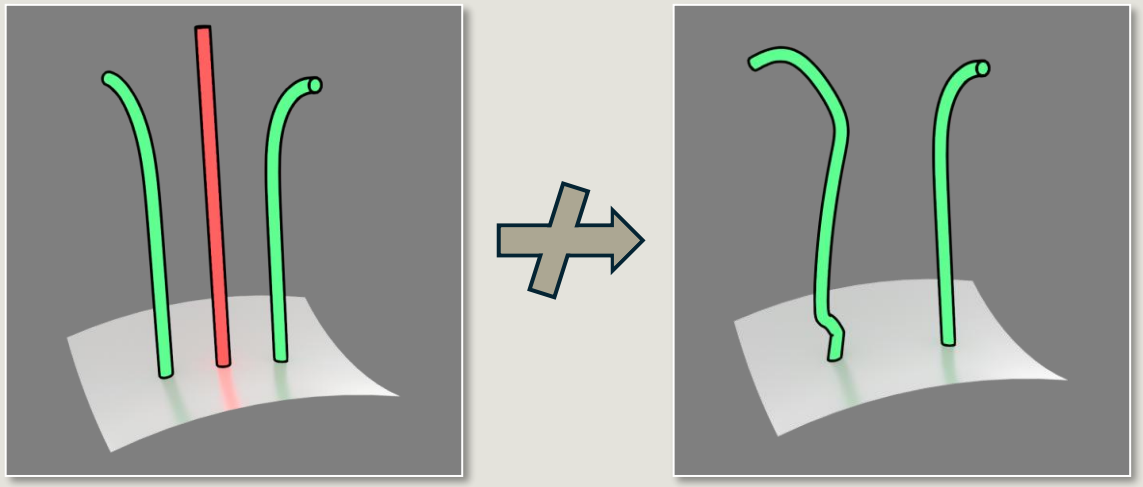
"**Distance**" between unstructured strands and procedural groom?

Procedural Groom

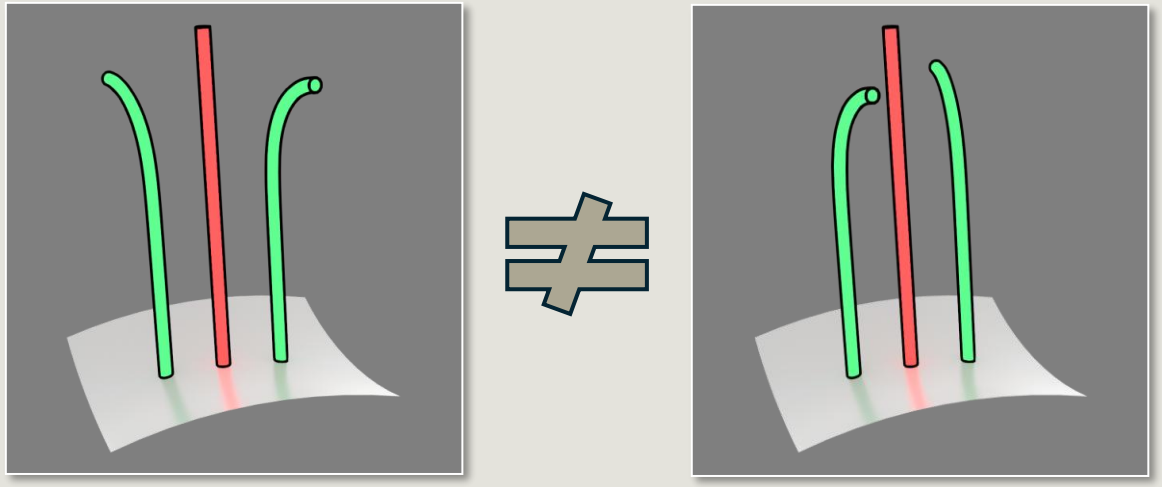
Unstructured Strands

Distance is Hard

Correct parameters ≠ Same strands!

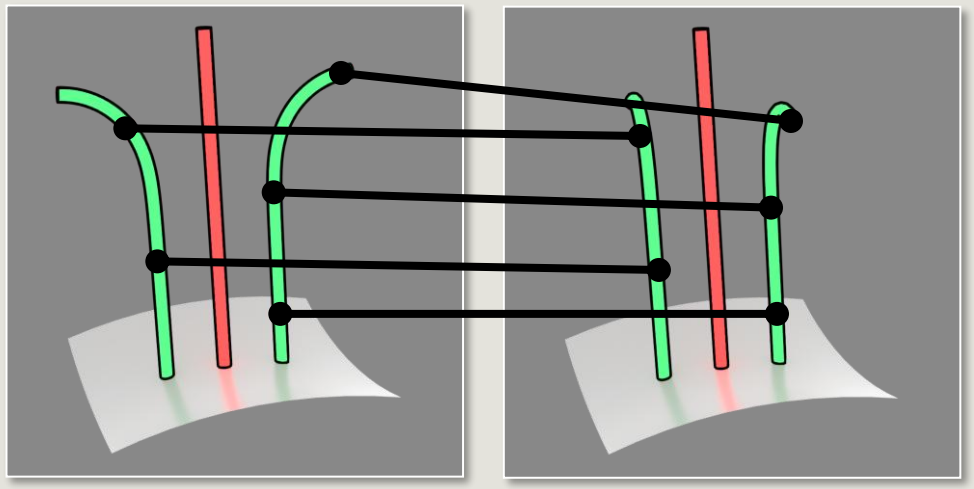


Cannot be represented
using 1 guide + bend

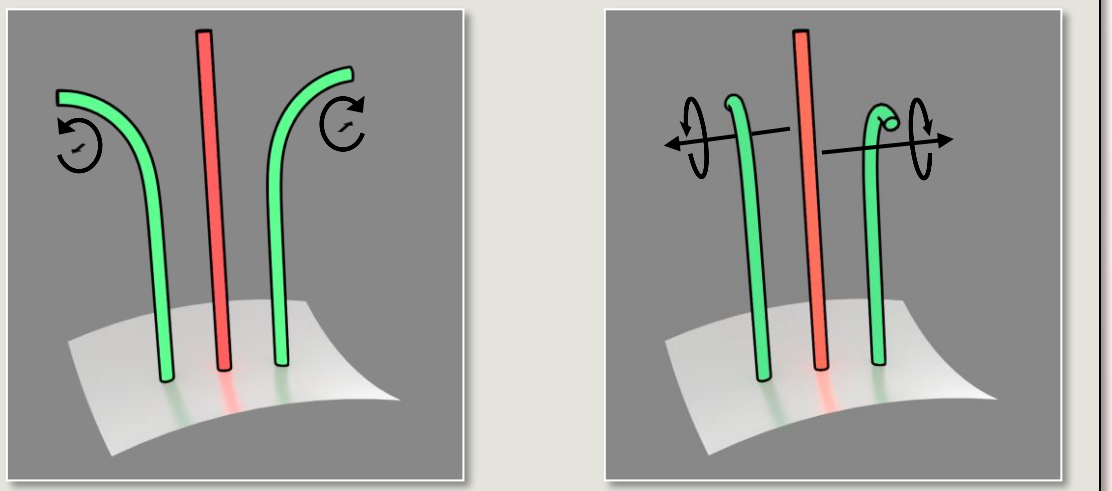


Same bend angle,
Different random axis

Naïve Distance Gives Incorrect Parameters



Distance between corresponding points on strands

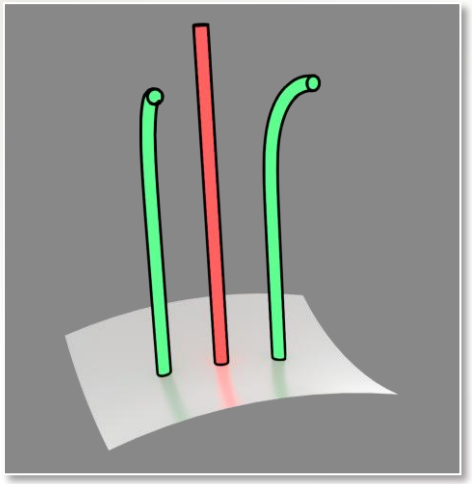


Target Strands

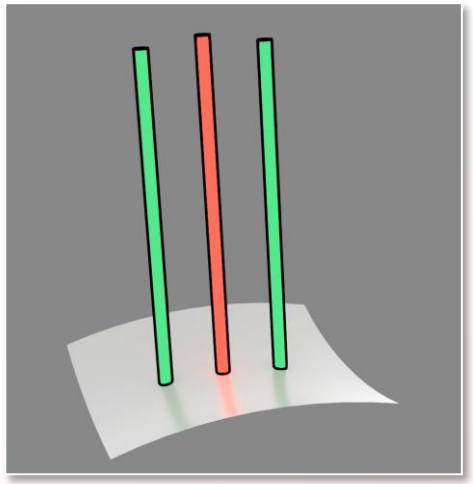
Optimized

Guide and Operator Ambiguity

Bend in Operator



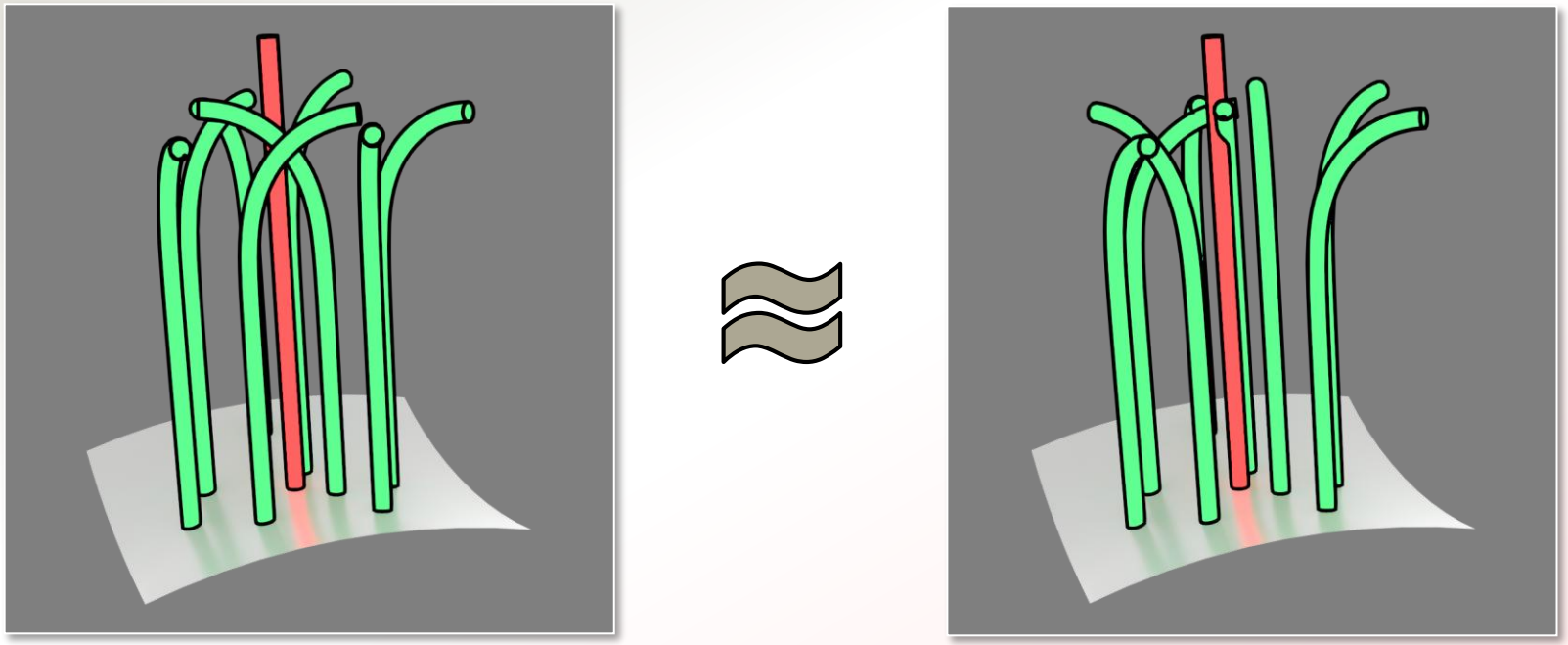
Target Strands



Optimized

Bend in Guides

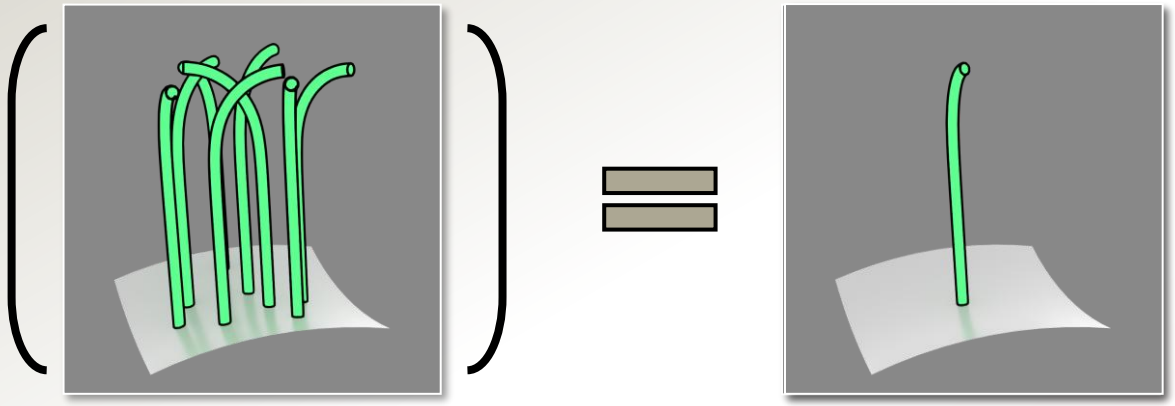
Key Idea: Look At Many Strands Together



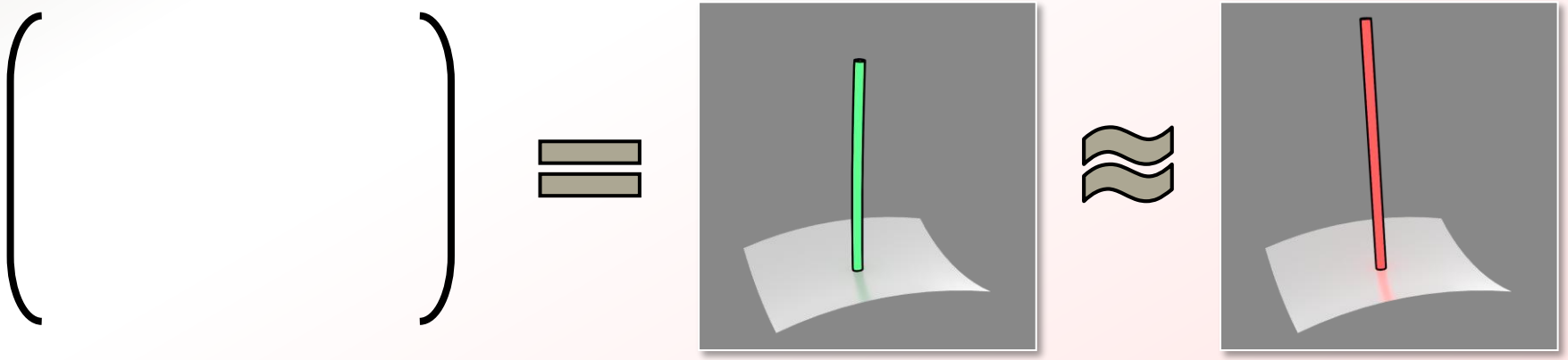
Guide Strands: Our Initialization

Assume guides are smooth

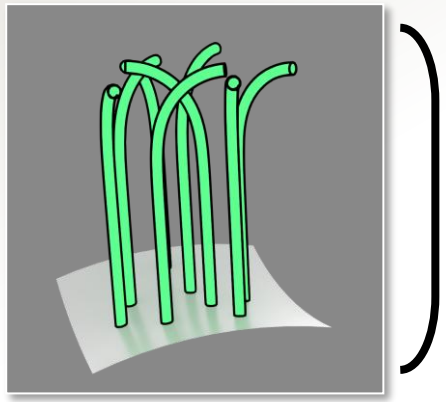
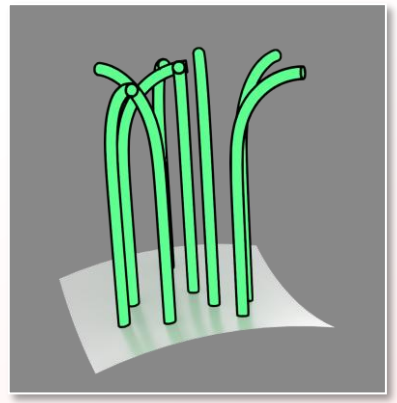
Average



Smooth



Guide Strands: Our Refinement

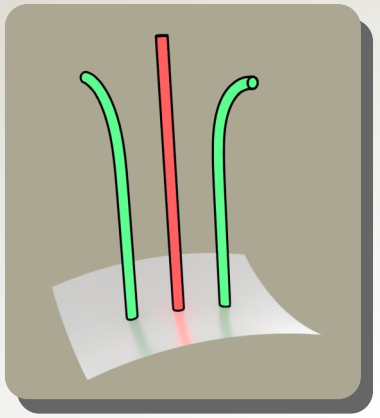
$$\text{Loss} \approx \left(\text{Average}\left(\text{  } \right) - \text{Average}\left(\text{  } \right) \right)^2$$

With smoothness using

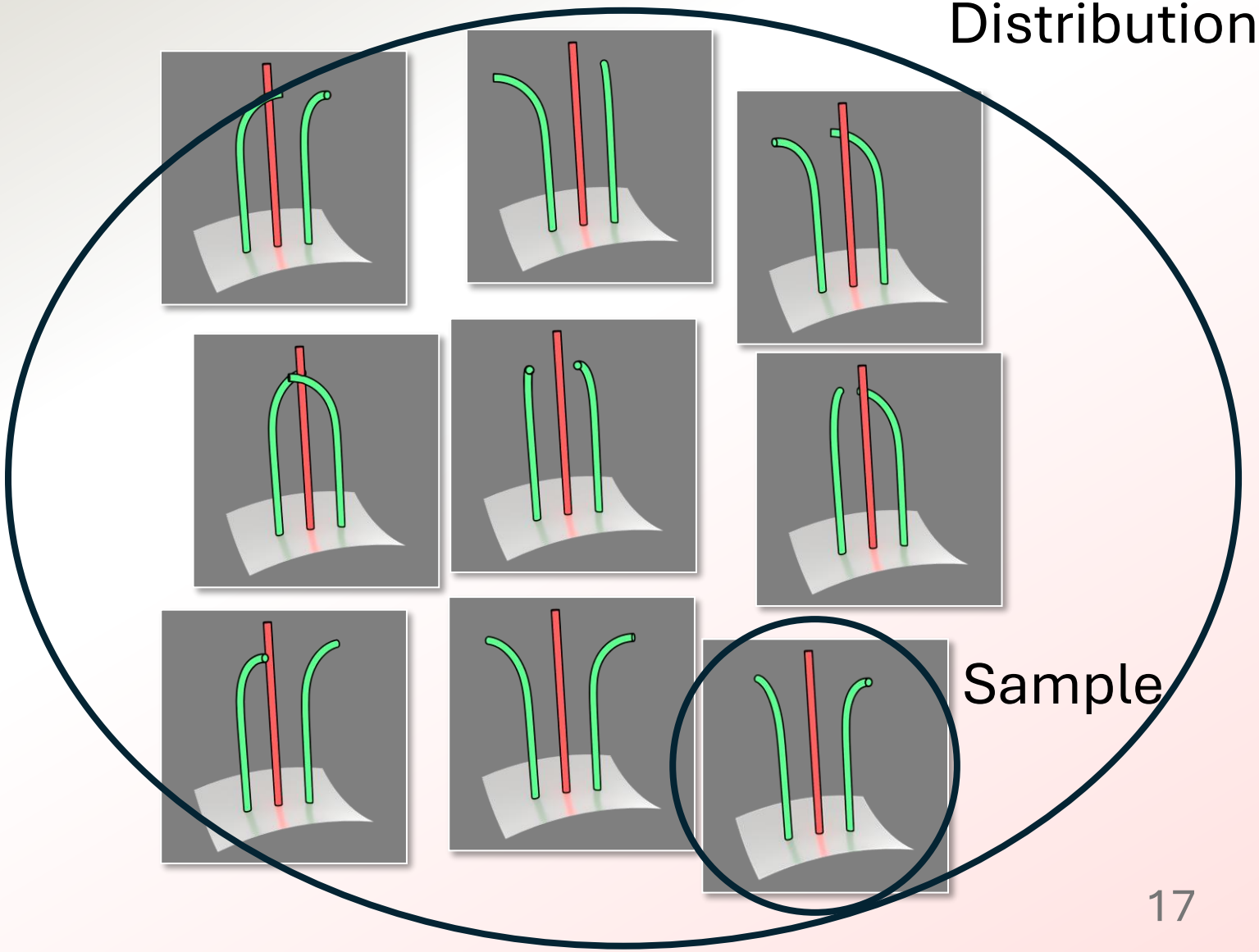
Smoothing through curvature reparameterization [Crane et al. 2013]

Edge-aware gradient filtering [Chang, Yang, Belhe et al. 2024]

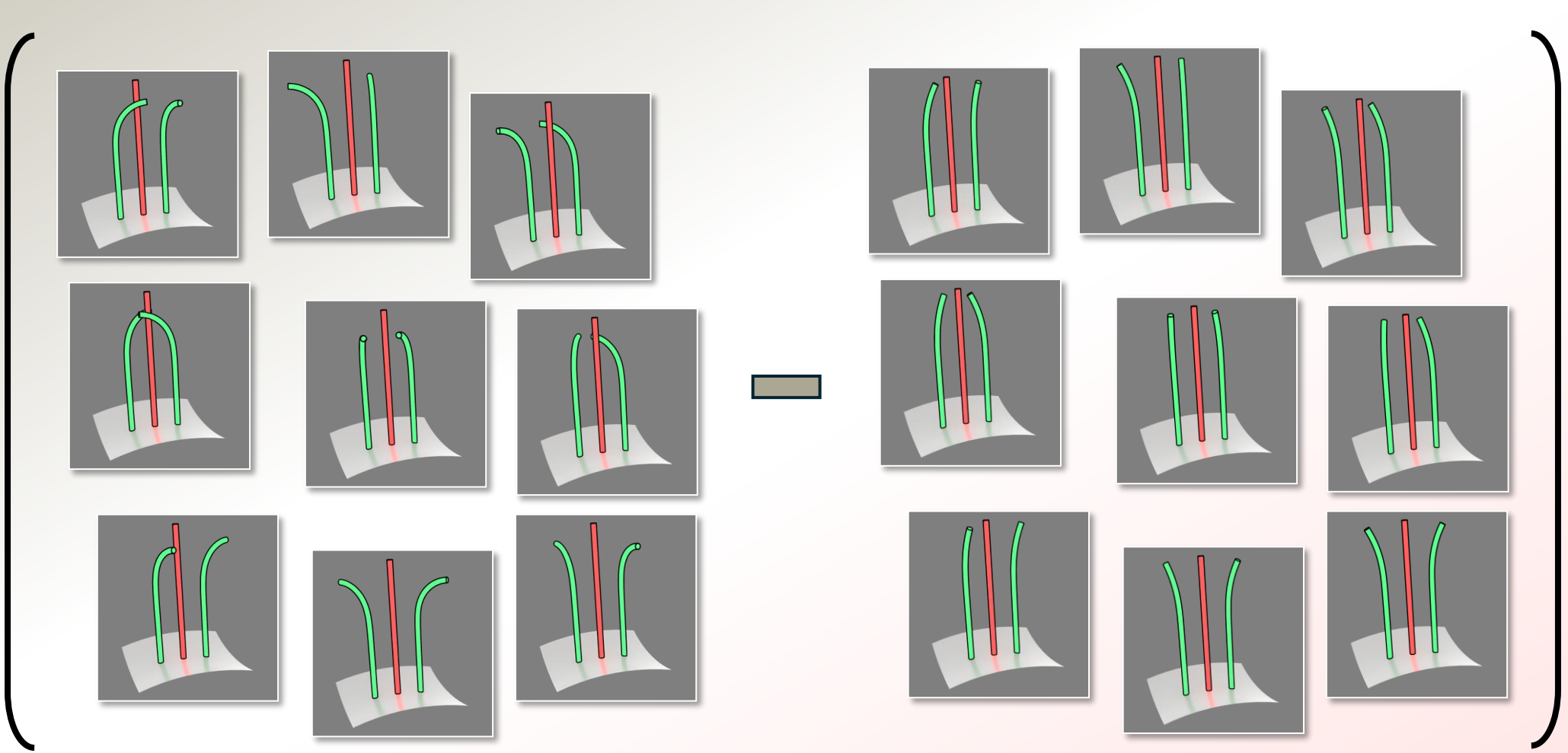
Operators: Strand Distributions



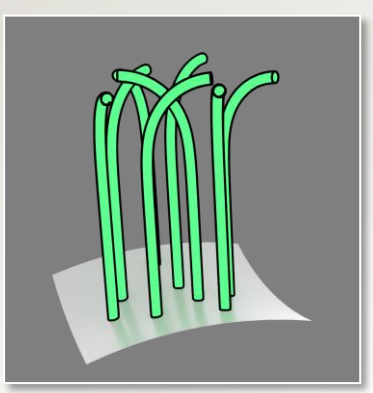
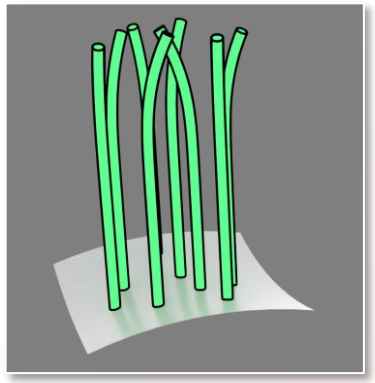
can generate any of



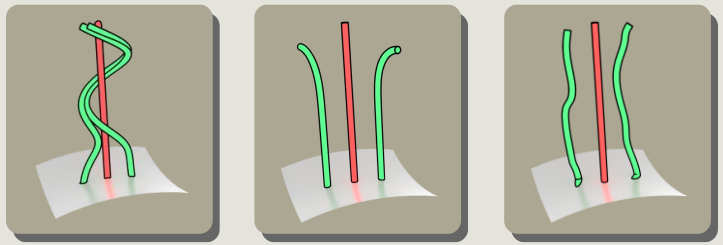
Operators: Distance Between Strand Distributions



Operators: Our Loss Functions

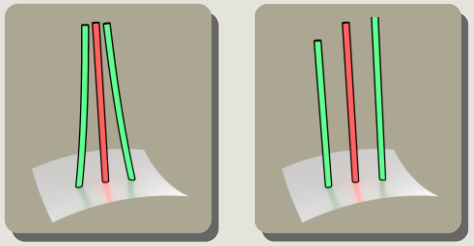
$$\left(\text{Distribution}\left(\text{  } \right) - \text{Distribution}\left(\text{  } \right) \right)^2$$

Shape Operators



Sliced Wasserstein Loss

Correlation Operators



Determinantal Point Process Loss

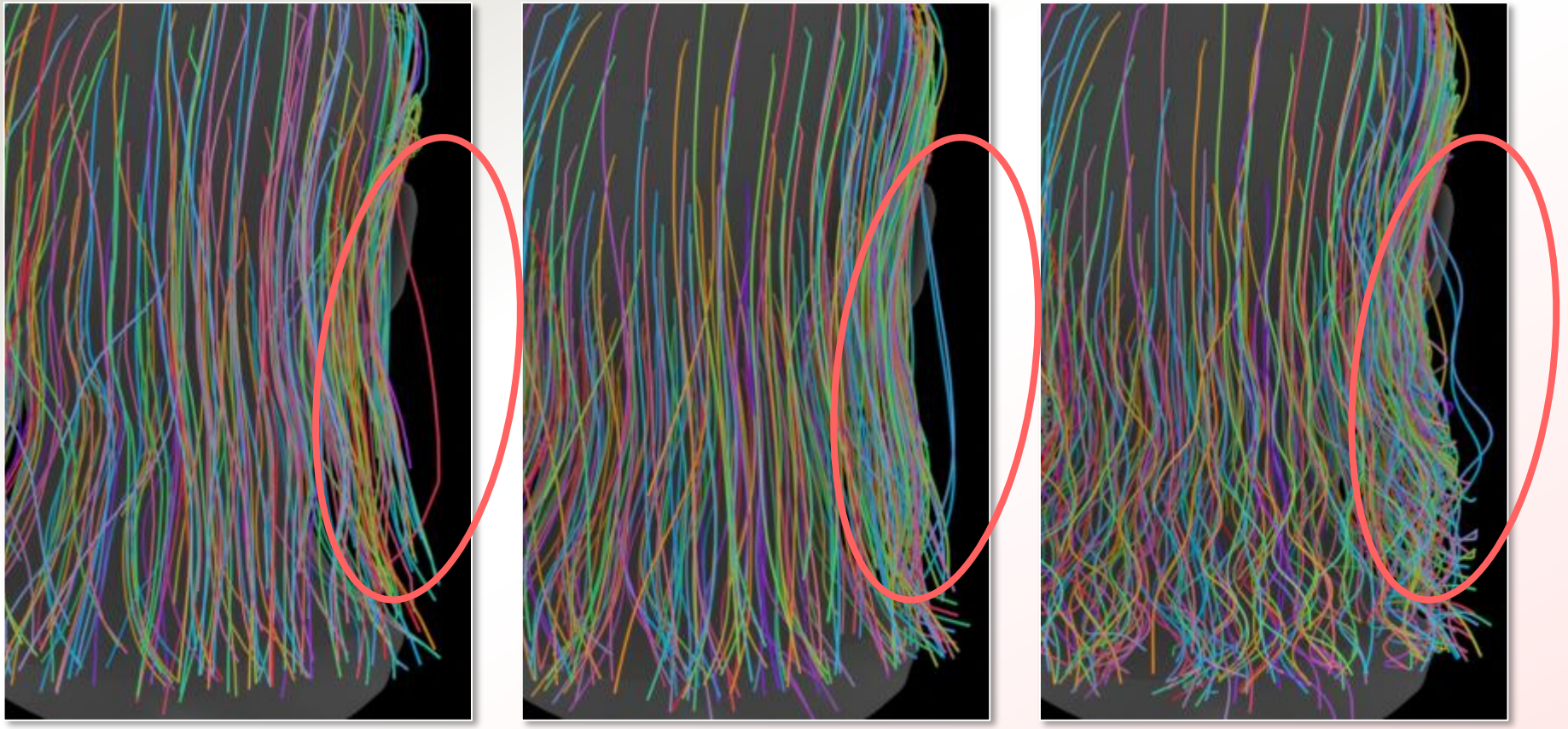
Results: Our Loss Gives Accurate Parameters

Target Groom

Our Groom

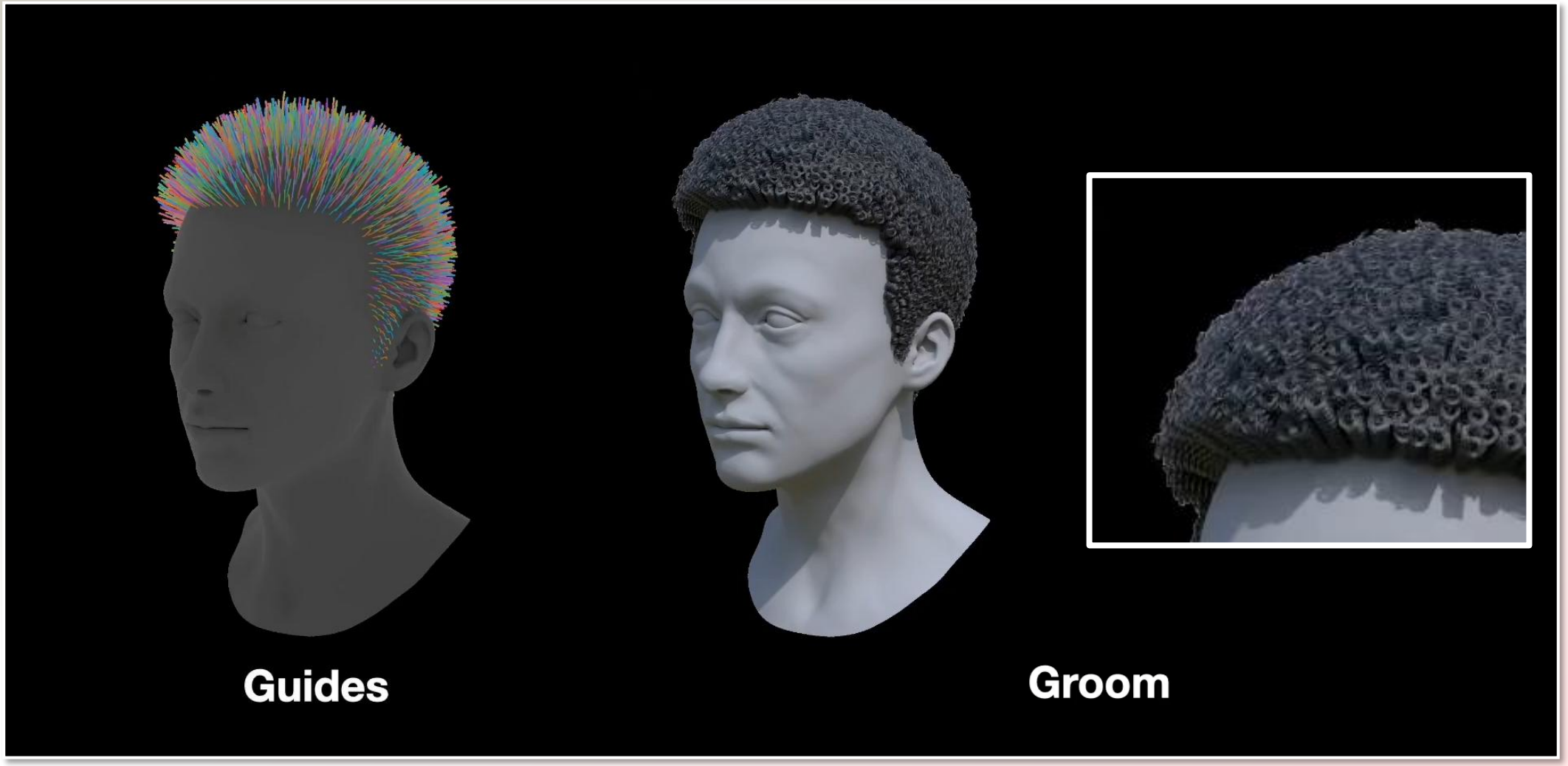
Naïve Loss

Results: Our Loss Gives Accurate Guides



Target Guides | Our Guides | Naïve Loss

Editing



Transforming Real Hair

< 15 min to optimize on RTX 4090

Editing Real Hair

Simulation

Thanks!

- Procedural grooms enable editing of real hair
- Open questions on selecting operators,
- Extending to production grooming pipelines

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Code: github.com/facebookresearch/iphg