SIGGRAPH ASIA 2014 SHENZHEN

# Capturing Braided Hairstyles

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# Braids in Real Life

Taylor Swift

Rihanna

# Braids in Animation


# Braids in VFX

Lionsgate

Warner Bros. Pictures

# Challenges

Reference photo

Geometric heuristics
[Luo et al. 2013]

Strand-based examples
[Hu et al. 2014]

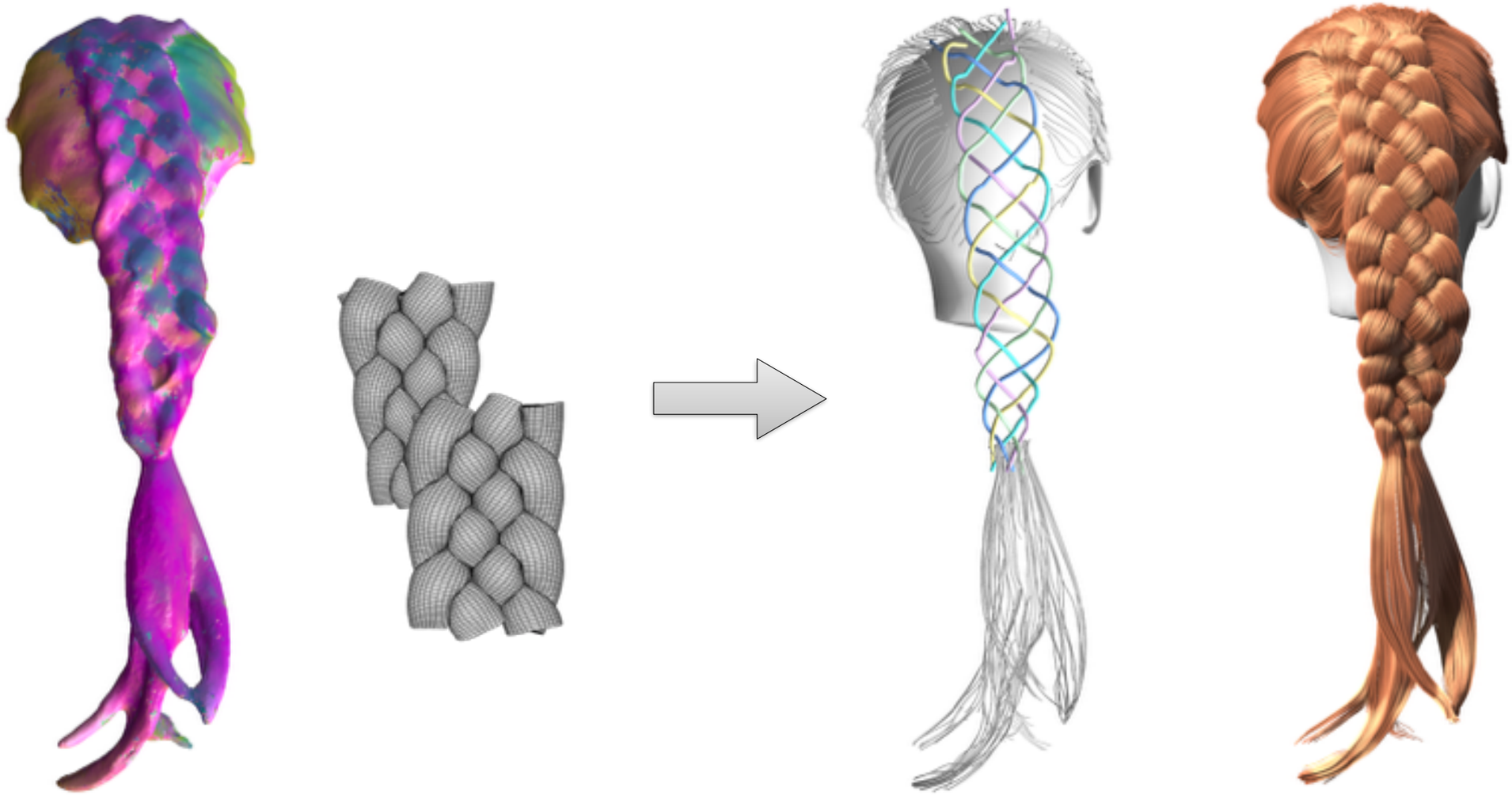
# Motivation


Repetition


Procedure

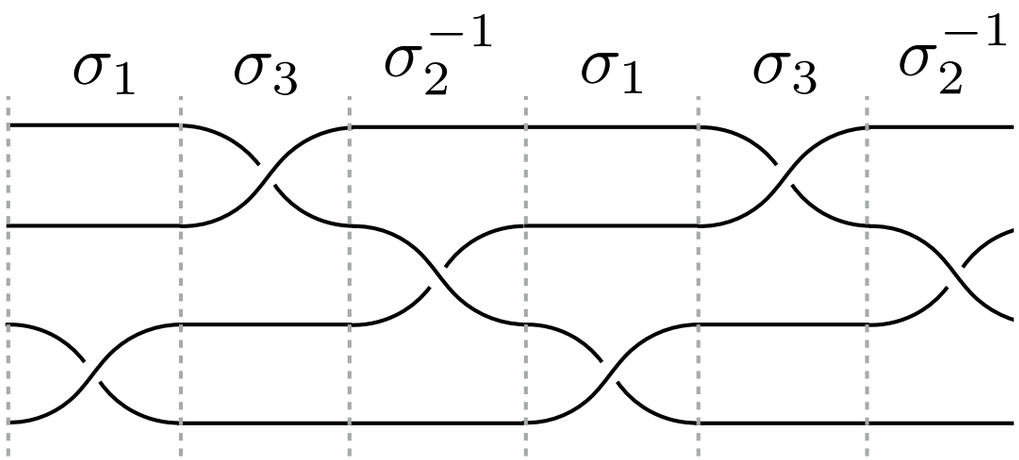
# Key Idea

- Data-driven reconstruction
- Procedurally generated examples

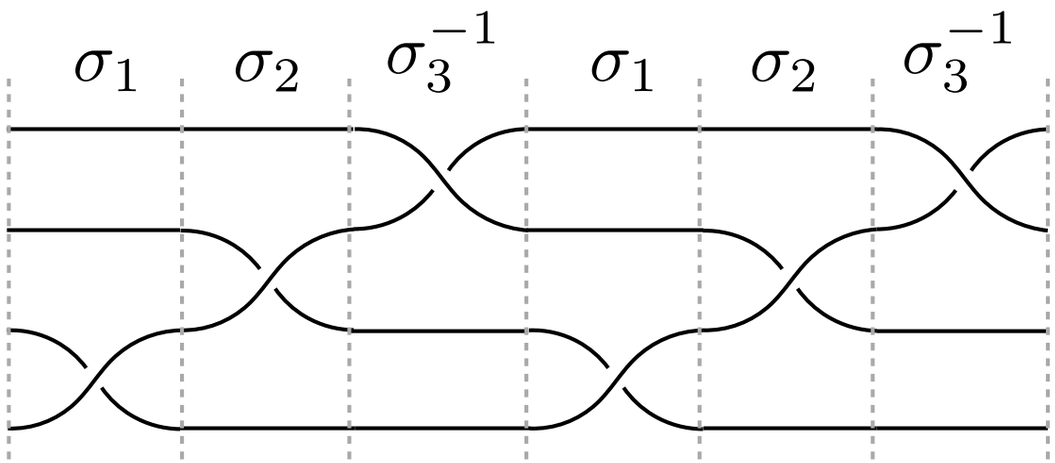


Captured input  Database  Extracted structure  Output strands

# Related Work: Braid Theory [Artin 1947]




4-strand basic braid

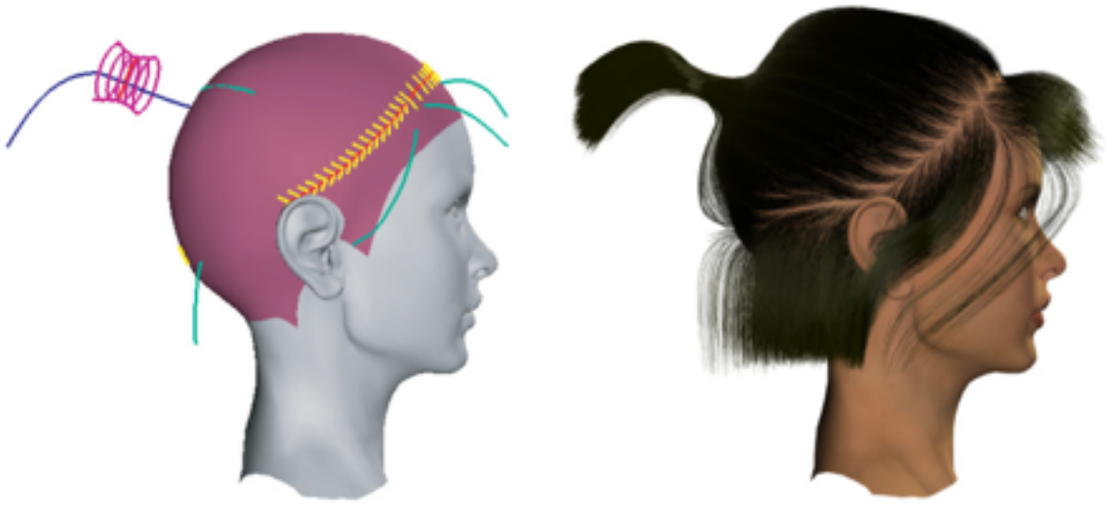



4-strand fishtail

# Related Work: Hair Modeling

[Choe and Ko 2005]

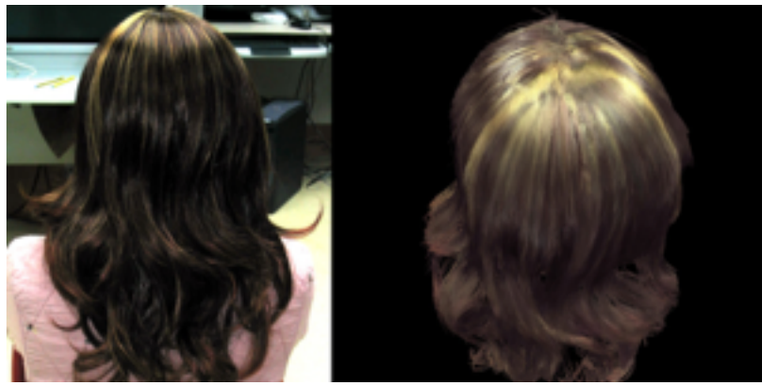
[Wither et al. 2007]



[Fu et al. 2007]

[Yuksel et al. 2009]

# Related Work: Hair Capture



[Wei et al. 2005]

[Paris et al. 2008]

[Jakob et al. 2009]

[Herrera et al. 2012]

[Chai et al. 2013]

[Luo et al. 2013]

[Echevarria et al. 2014]

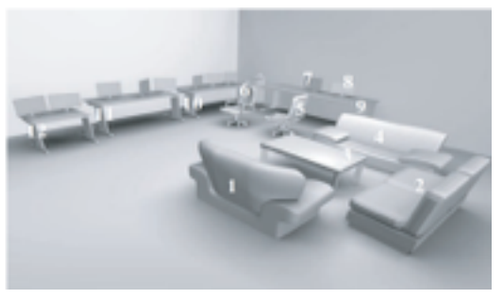
[Hu et al. 2014]

[Xu et al. 2014]

# Related Work: Structure-aware shape processing

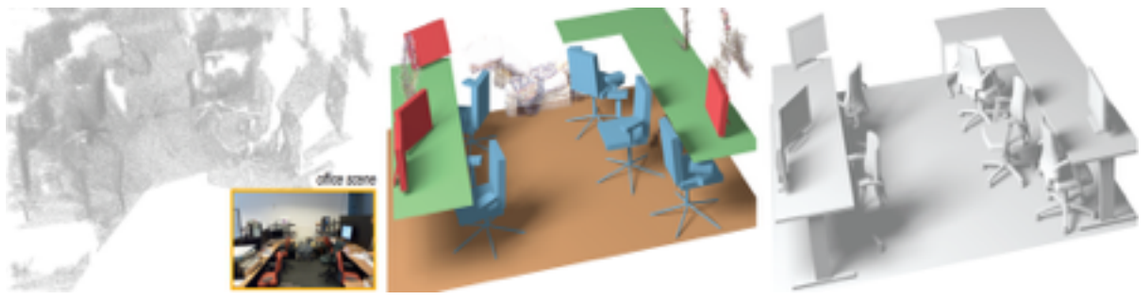
[Nan et al. 2012]

[Shen et al. 2012]



[Shao et al. 2012]

[Bradley et al. 2013]



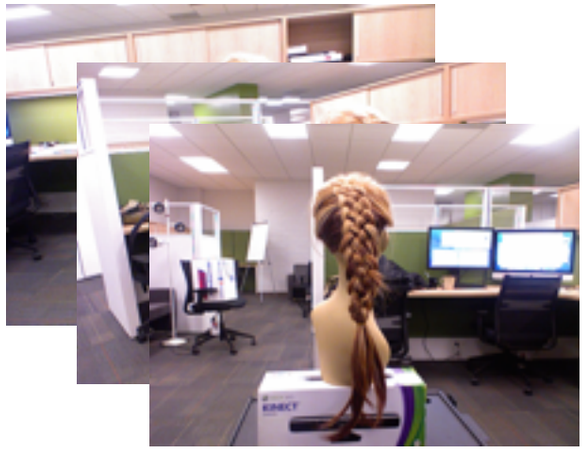
[Kim et al. 2012]

[Li et al. 2010]

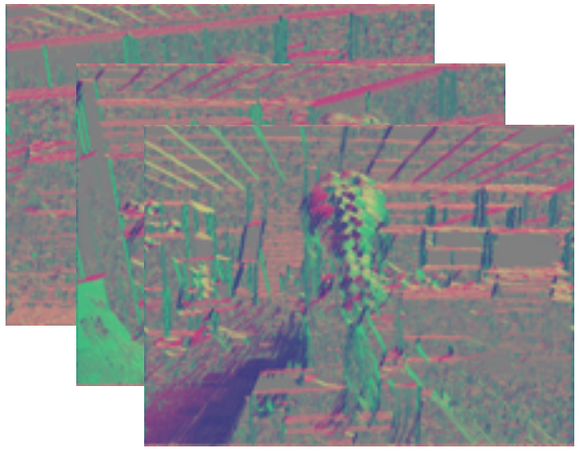
[Li et al. 2011]

[Huang et al. 2013]

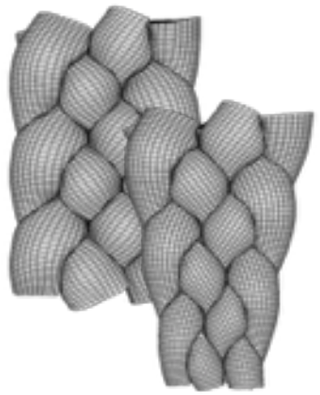
# Overview



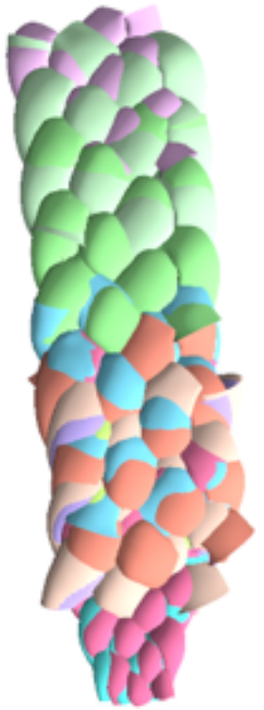
Input photos



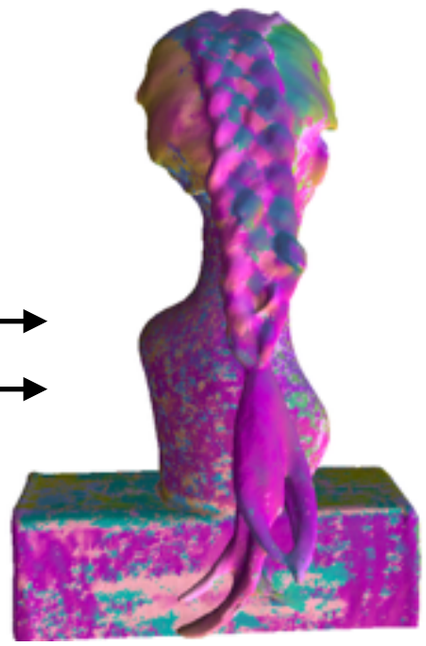
2D orientation maps



Database



Input mesh

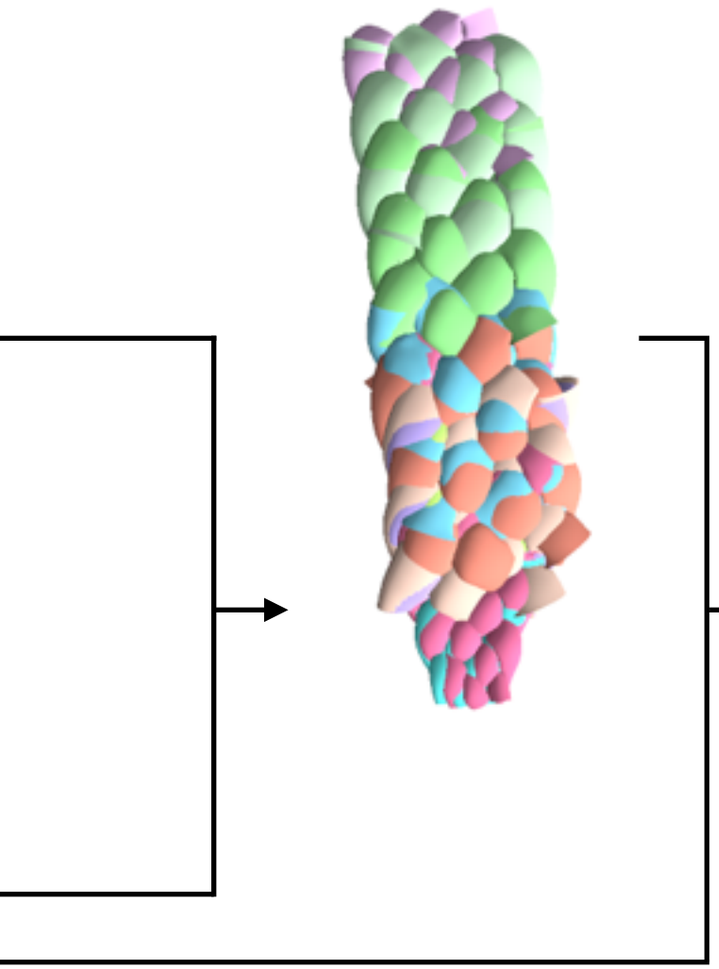


3D orientation field

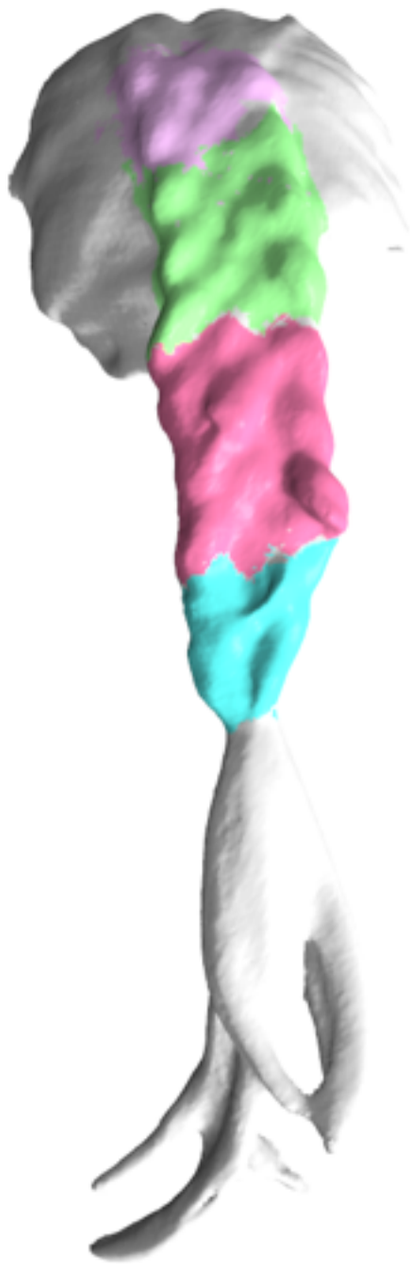
Cleaned mesh

Fitting result

# Overview



Fitting result

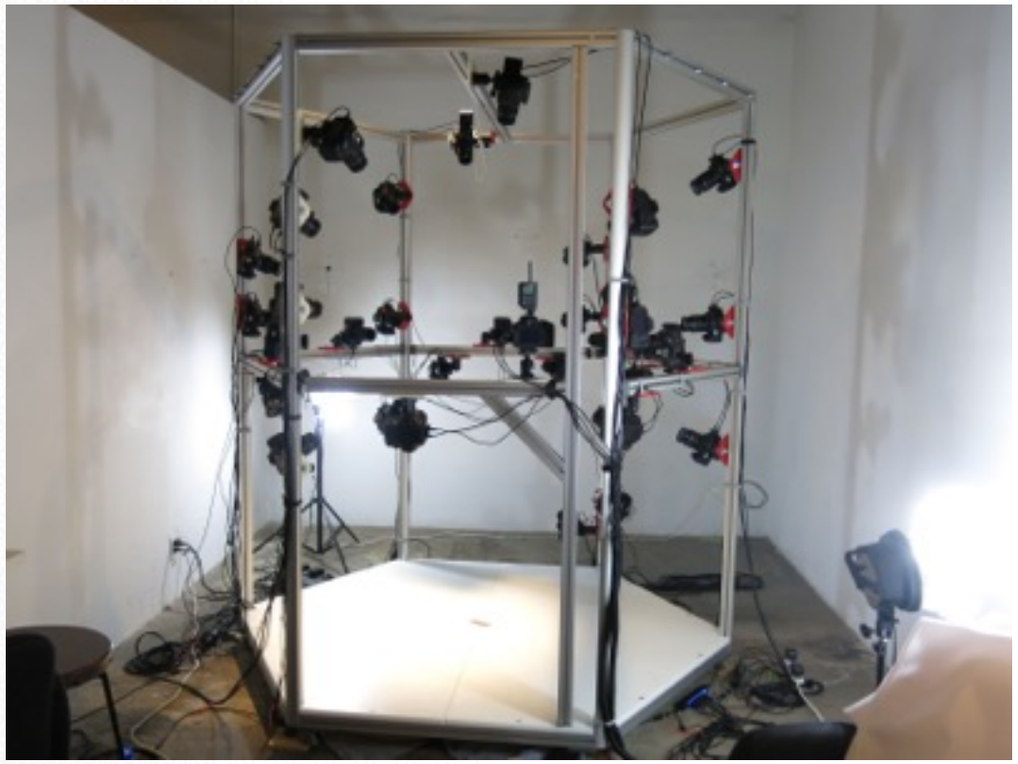


Labeling result

Extracted structure

Output strands

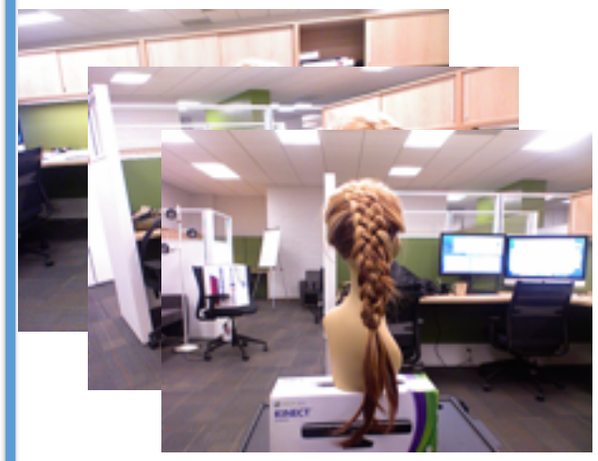
# Capture Setup



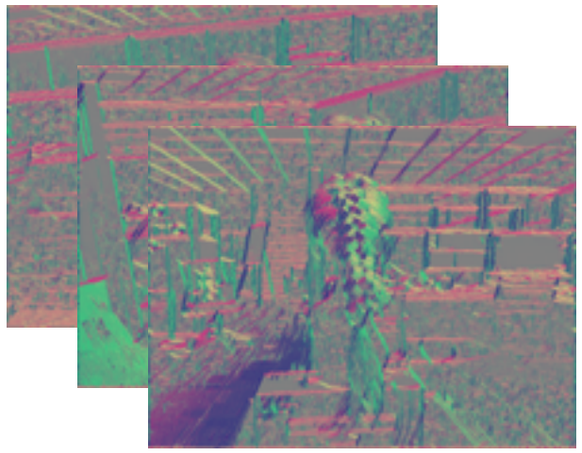
Multi-view stereo

Hand-held Kinect

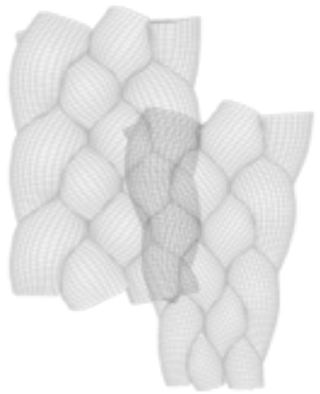
# Pre-processing



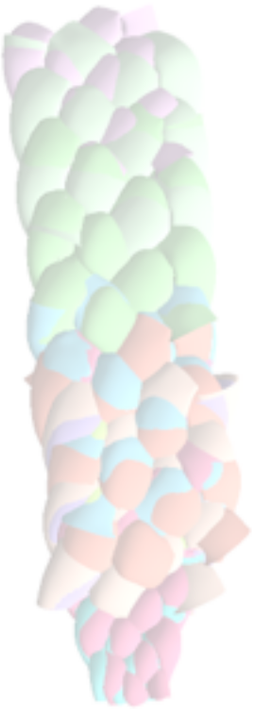
Input photos



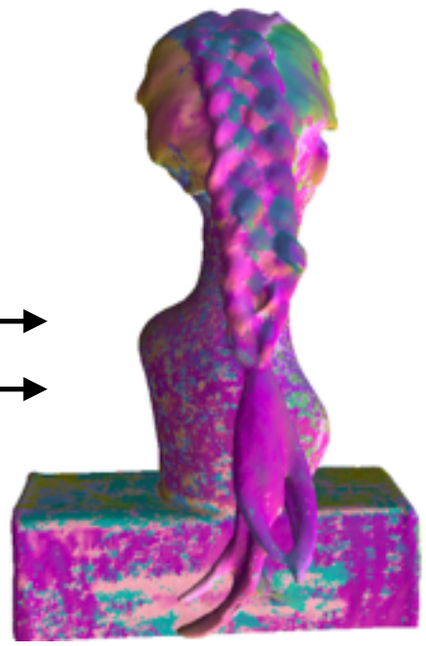
2D orientation maps



Database



Input mesh

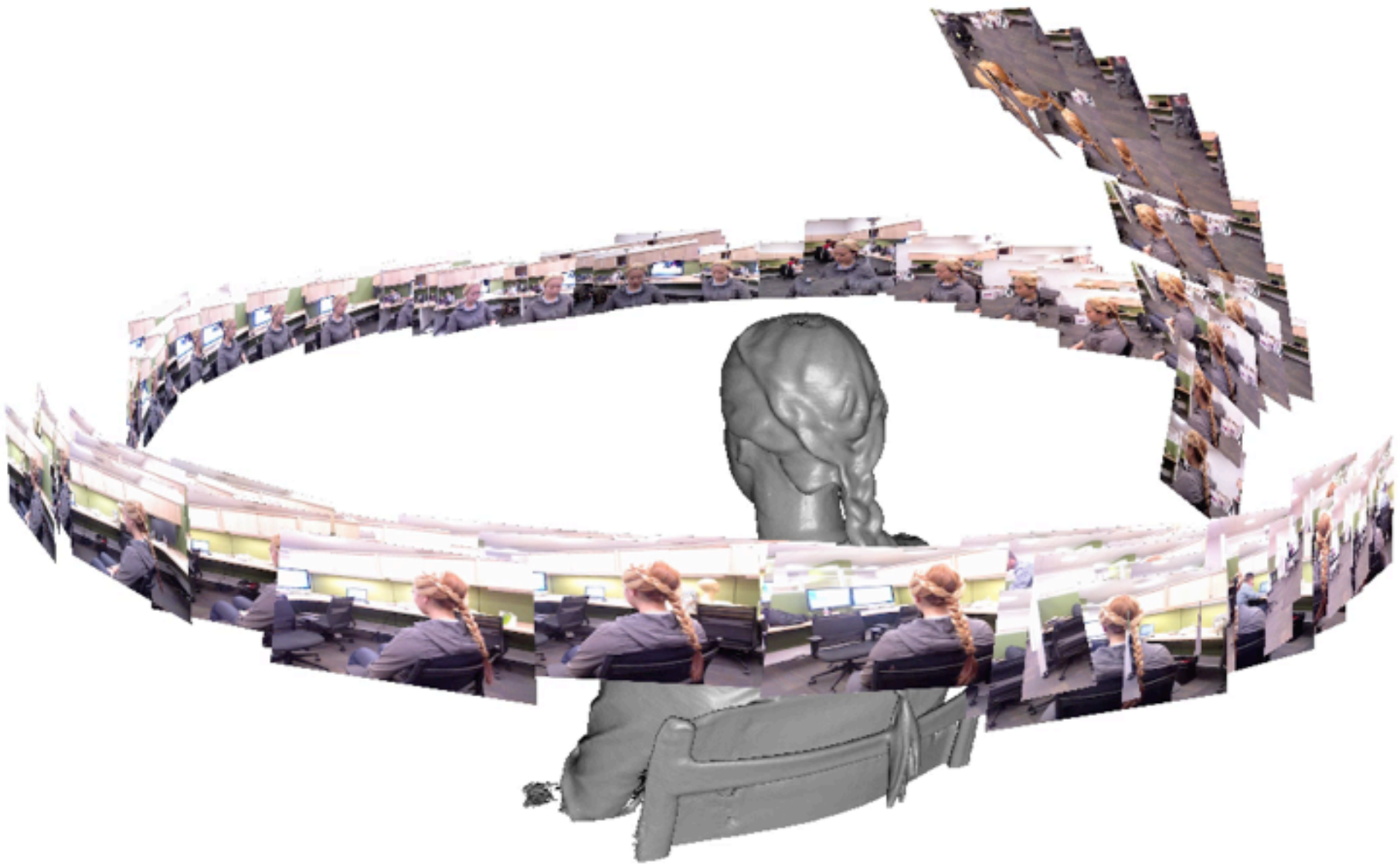


3D orientation field

Cleaned mesh

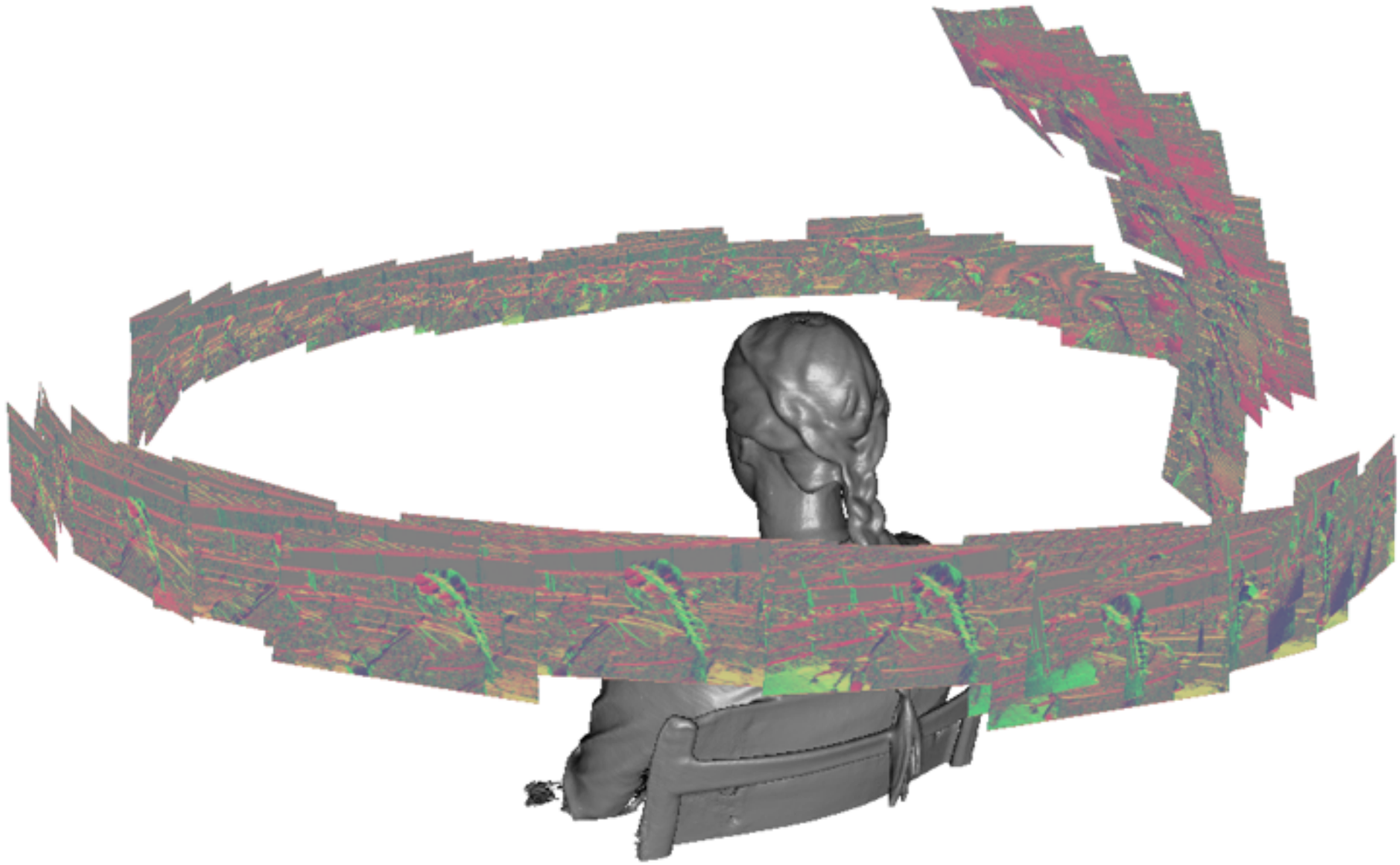
Fitting result

# Pre-processing



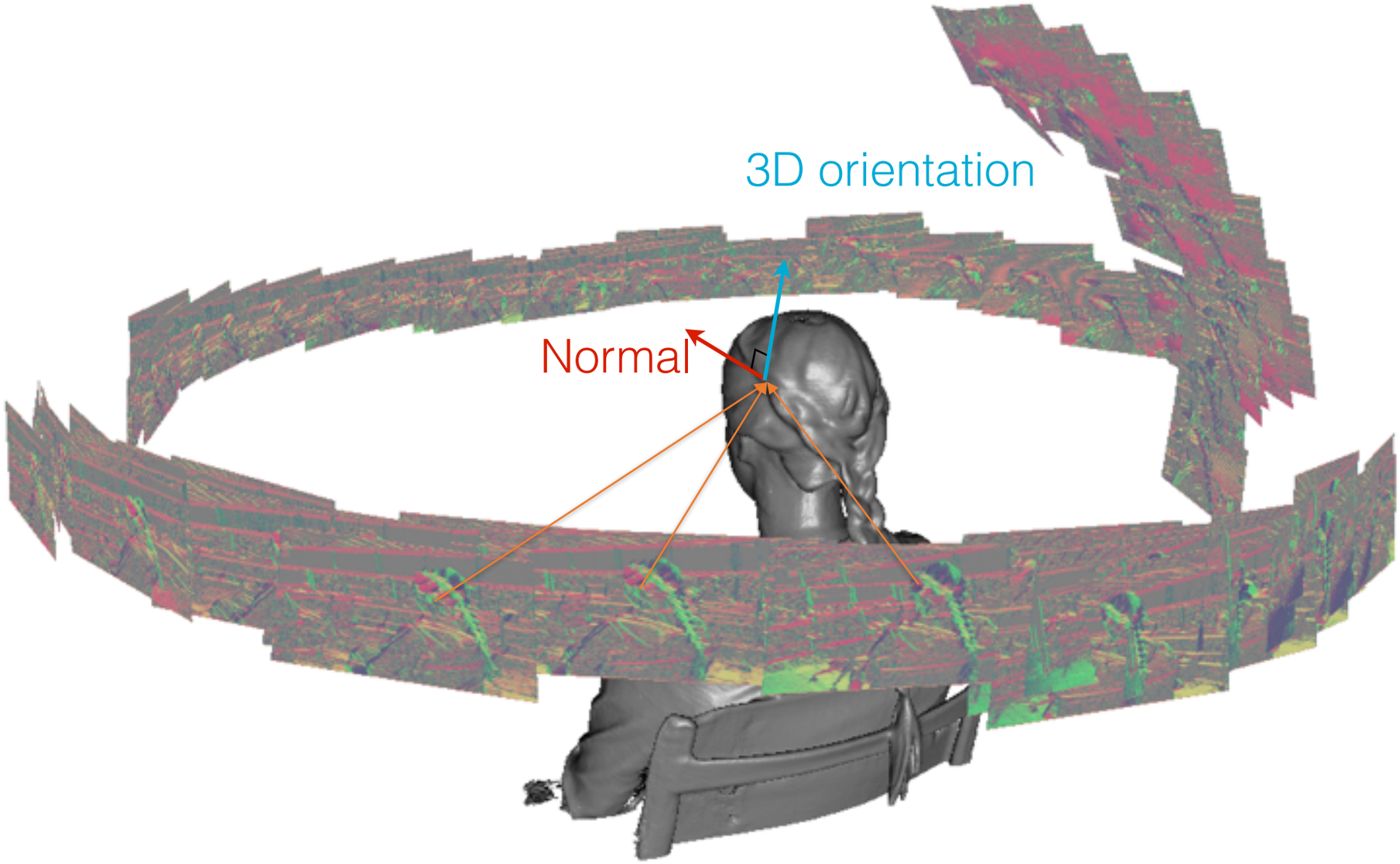
Kinect Fusion [Newcombe et al. 2011]

# Pre-processing

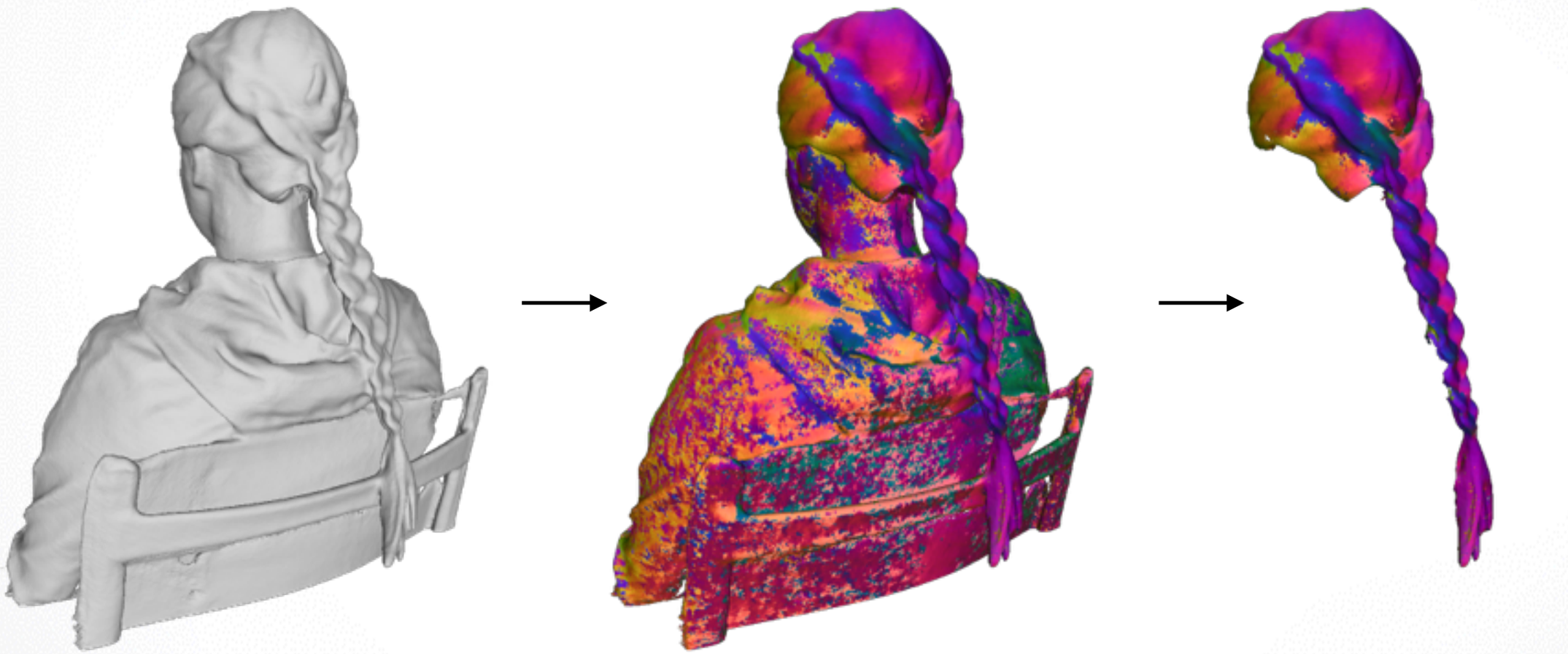


Detect dominant local orientation [Pair et al. 2004]

# Pre-processing



# Pre-processing



Input mesh

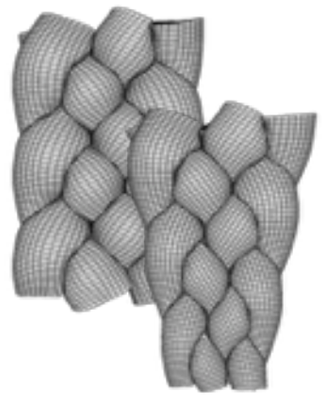
3D orientation field

Cleaned mesh

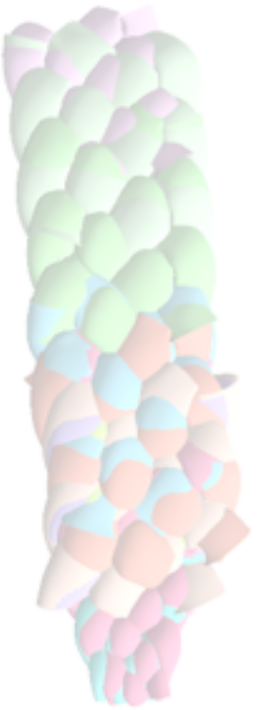
# Procedural Model

Input photos

2D orientation maps



Database



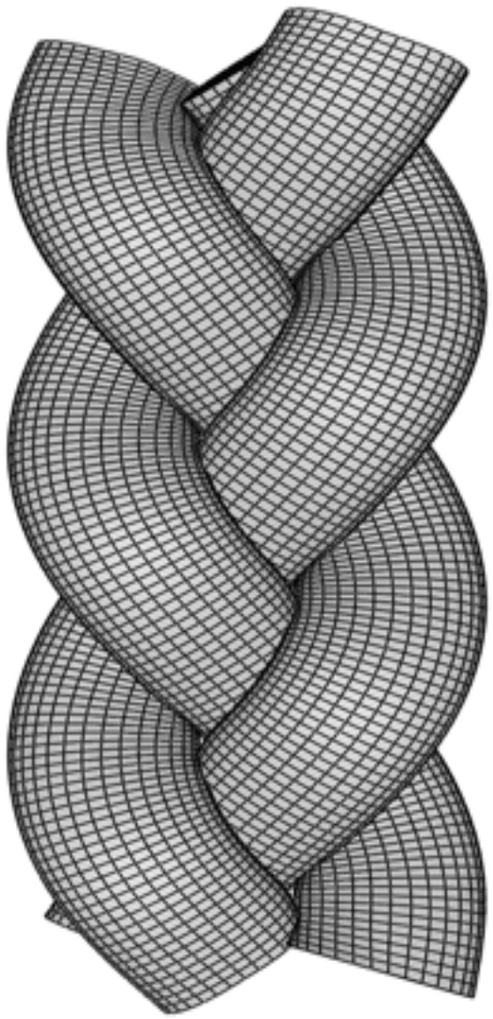
Input mesh

3D orientation field

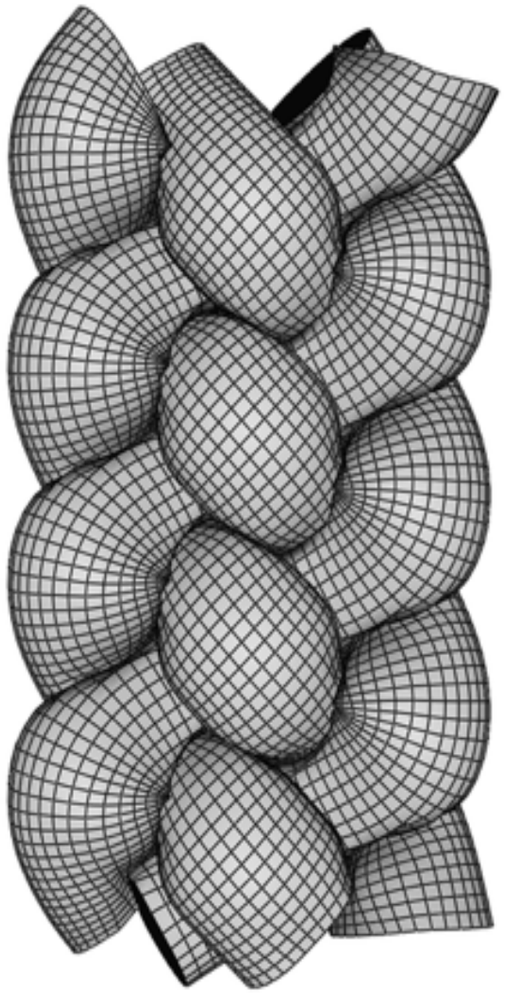
Cleaned mesh

Fitting result

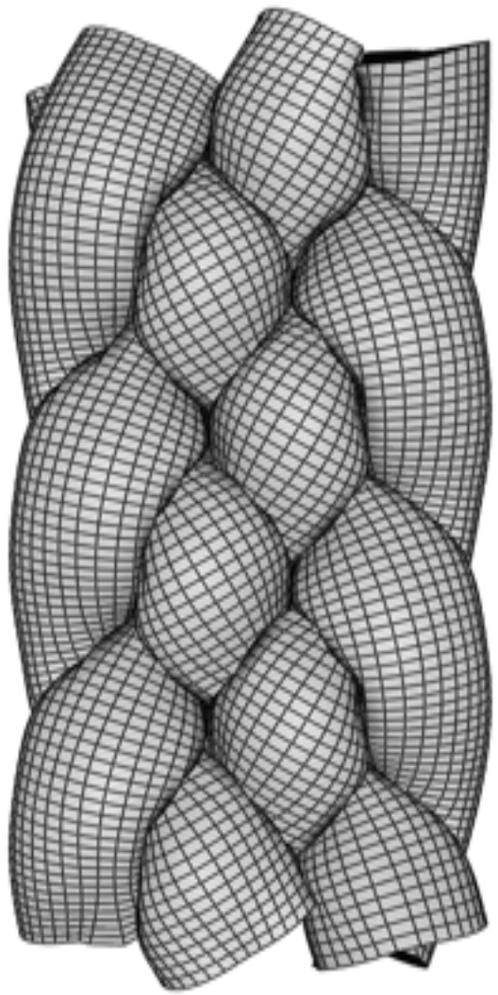
# Procedural Model



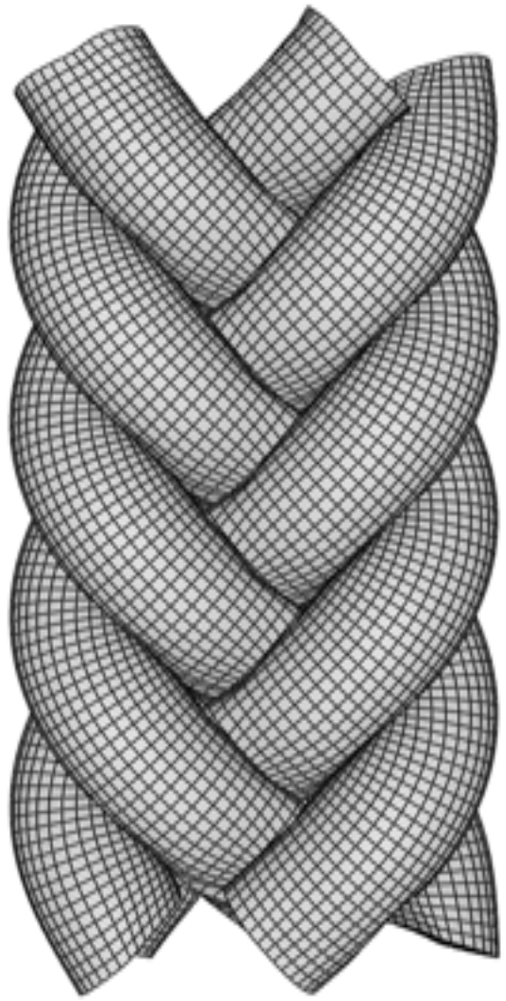
Basic
braid



Four-strand
braid



Five-strand
Dutch braid



Fishtail
braid

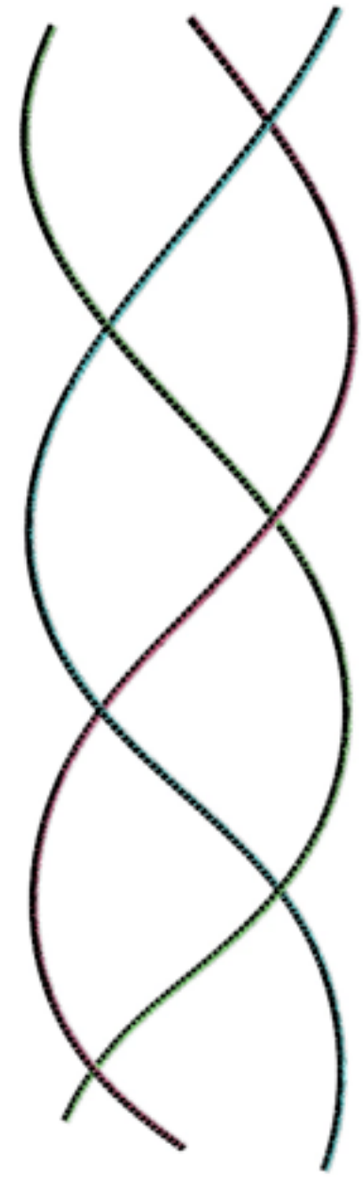
# Procedural Model

## Basic braid:

$$L_0 : x = a\sin(t), \quad y = t,\ z = b\sin(2t)$$
$$L_1 : x = a\sin(t + 2\pi/3), \ y = t,\ z = b\sin(2(t + 2\pi/3))$$
$$L_2 : x = a\sin(t + 4\pi/3), \ y = t,\ z = b\sin(2(t + 4\pi/3))$$

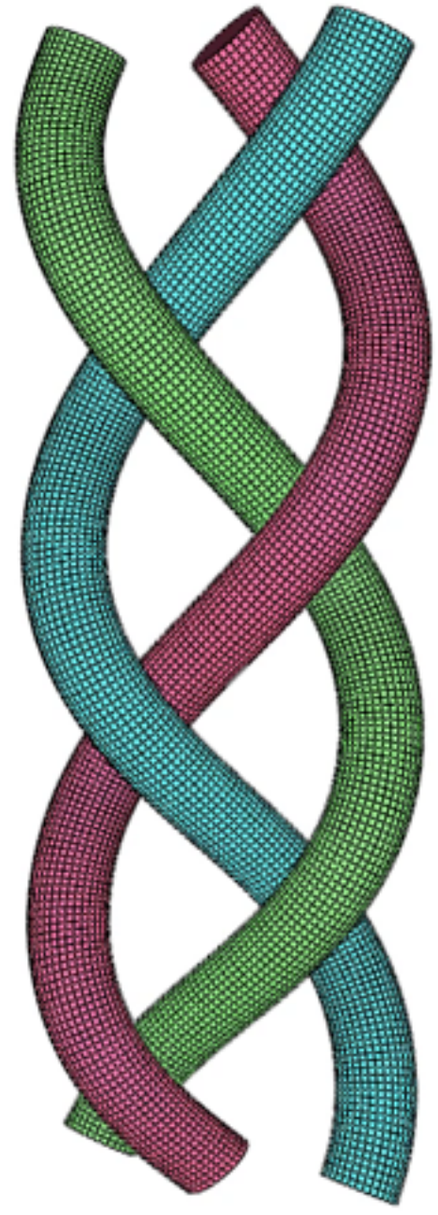
# Procedural Model

Expand



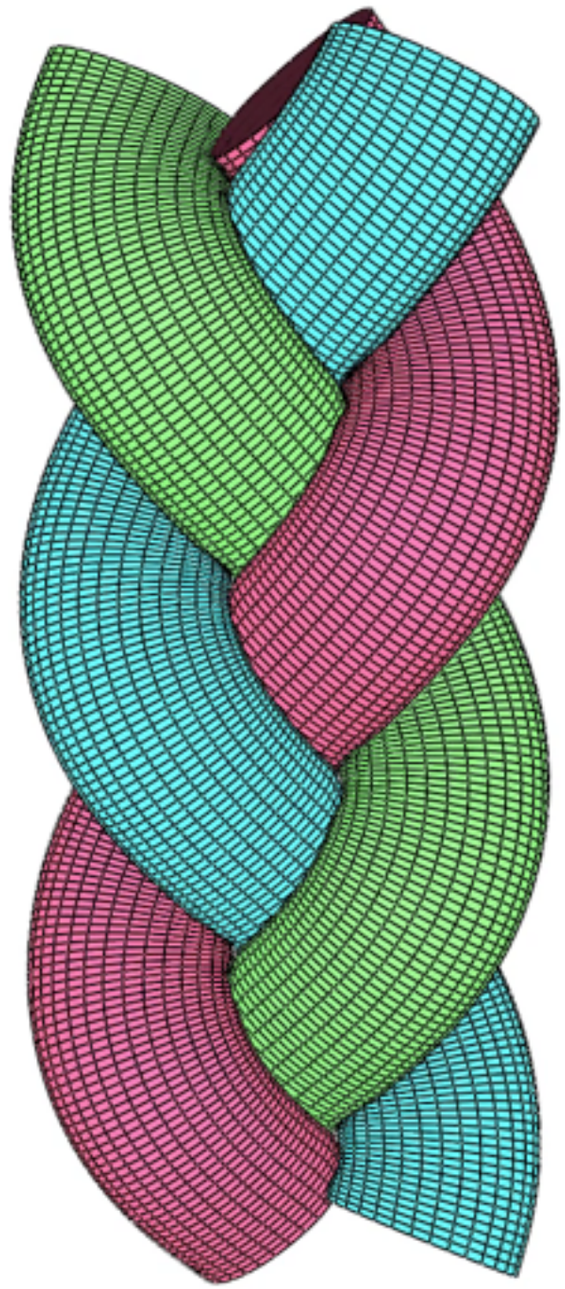
# Procedural Model

Expand

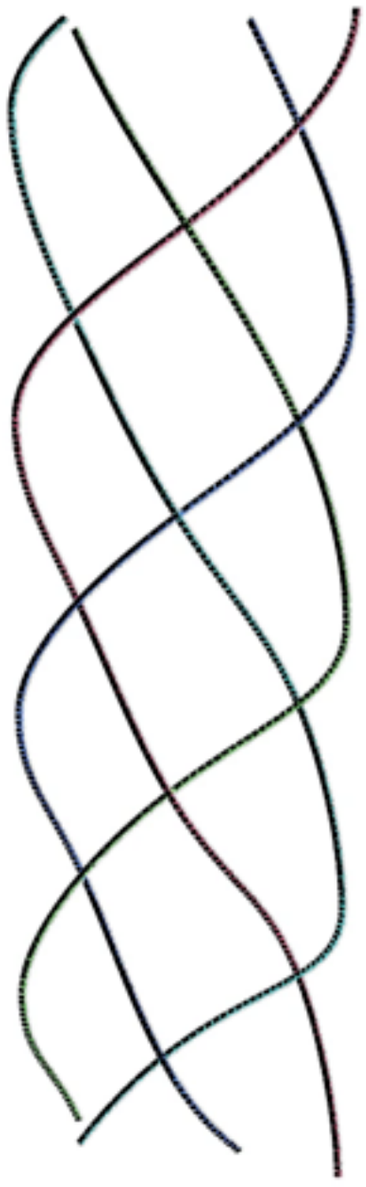


# Procedural Model

Expand

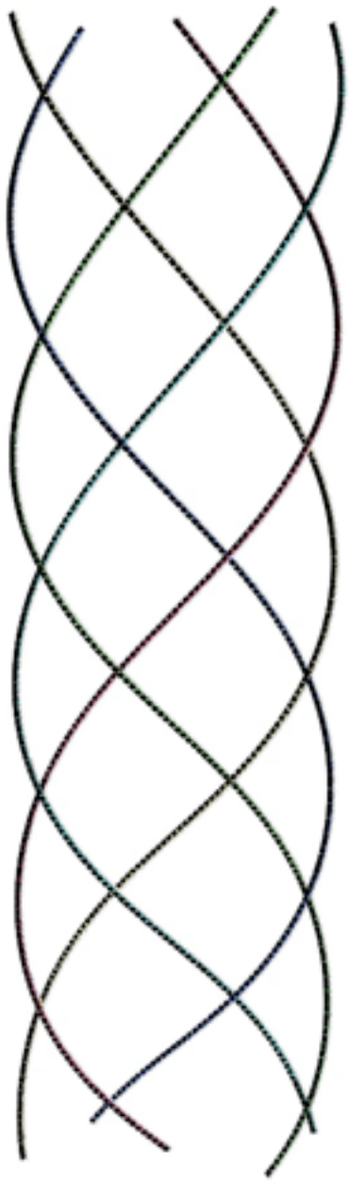


# Procedural Model



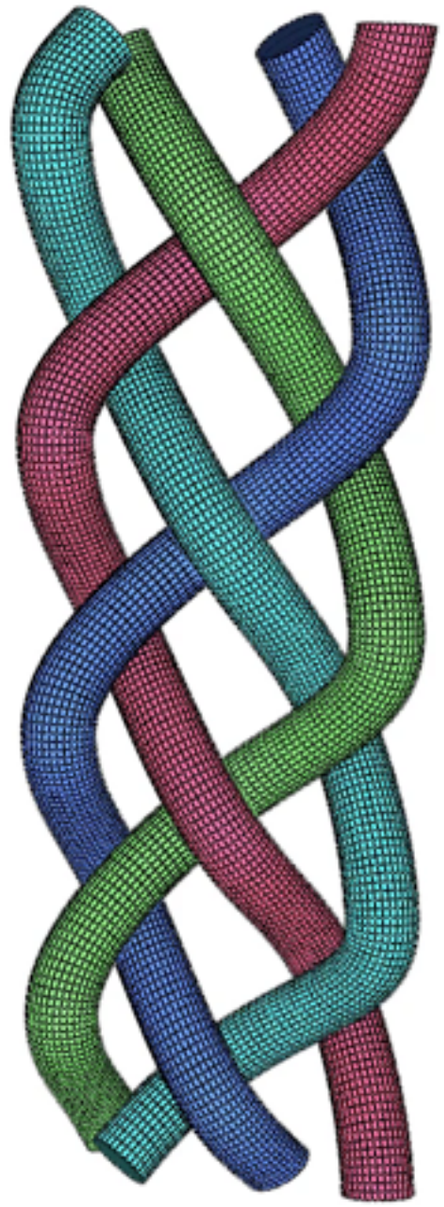
Four-strand
braid

Five-strand
Dutch braid

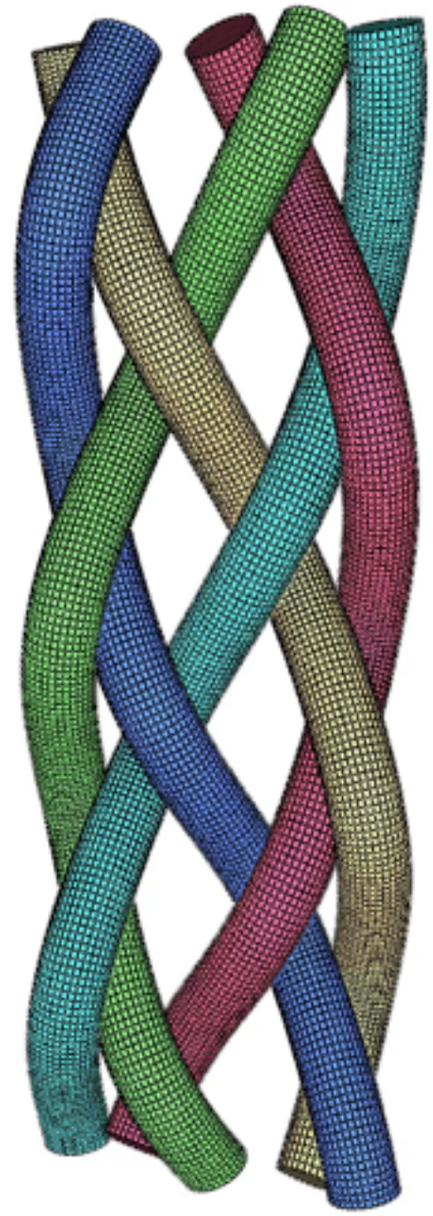


Fishtail
braid

# Procedural Model



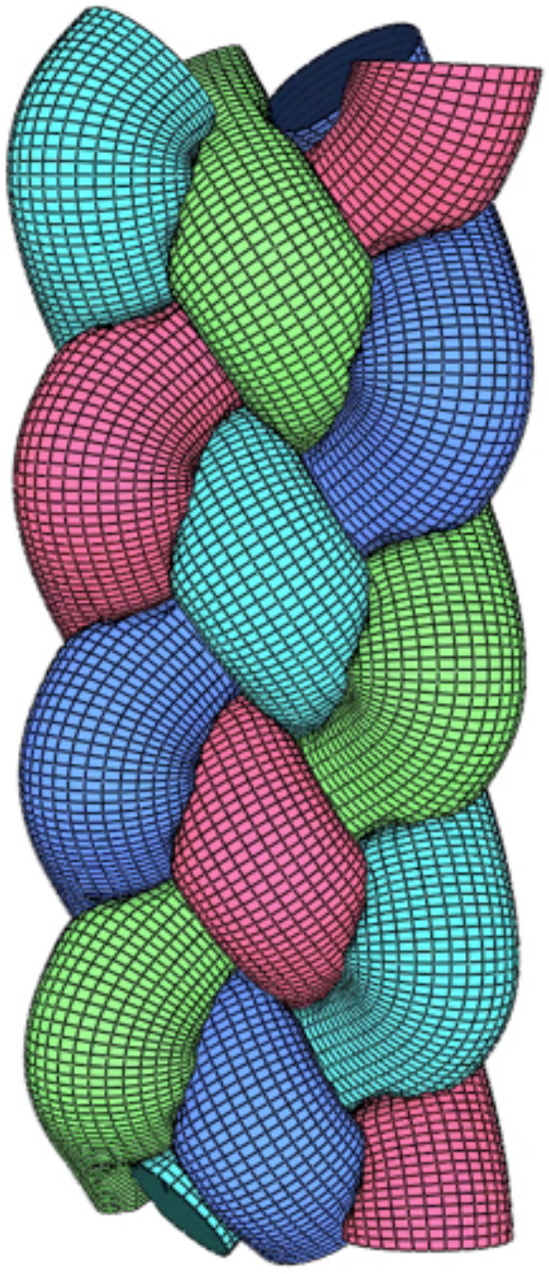
Four-strand
braid



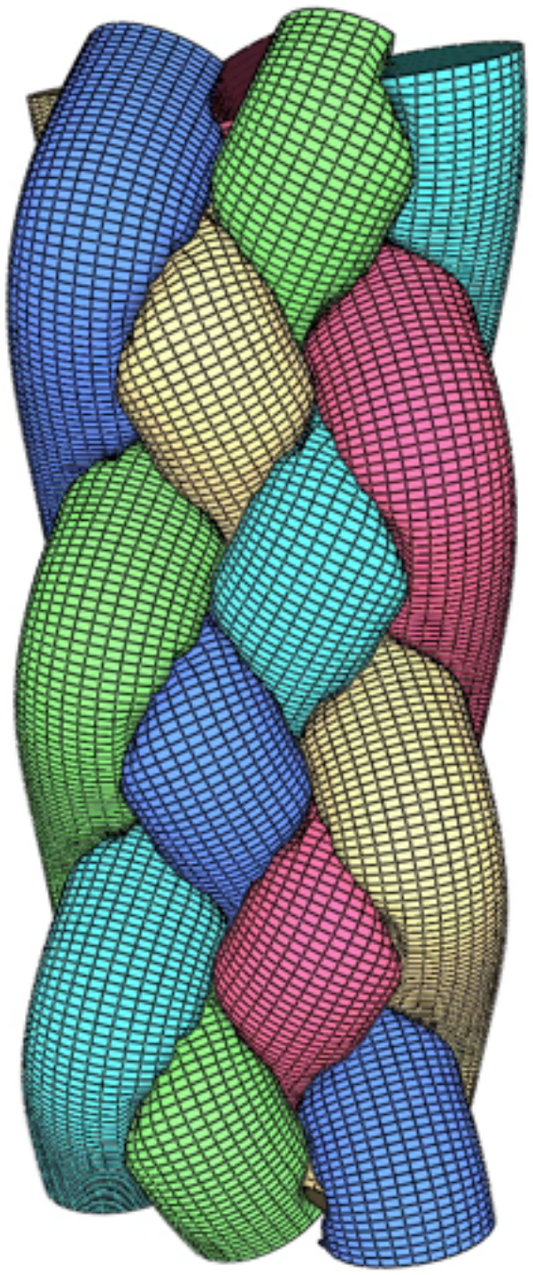
Five-strand
Dutch braid

Fishtail
braid

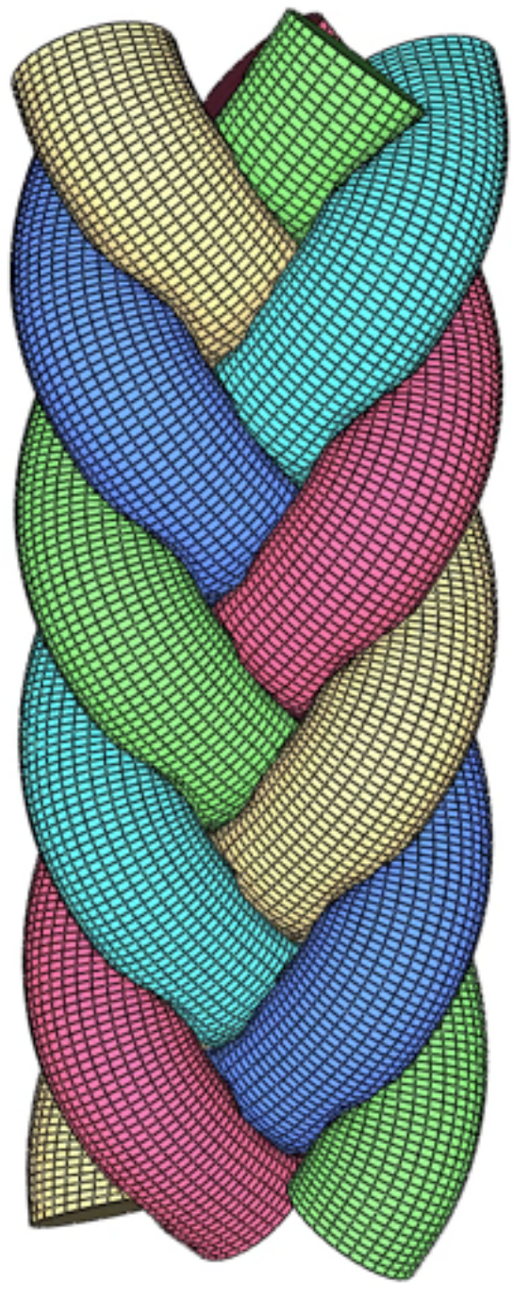
# Procedural Model



Four-strand
braid

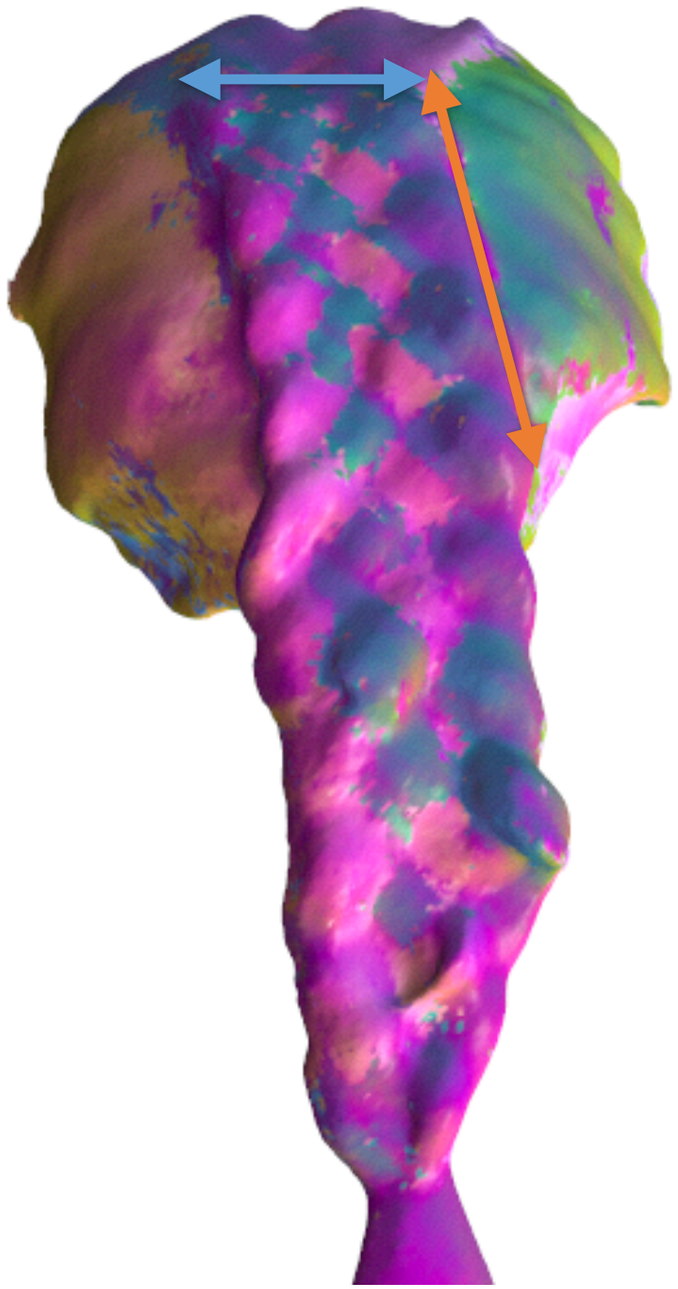


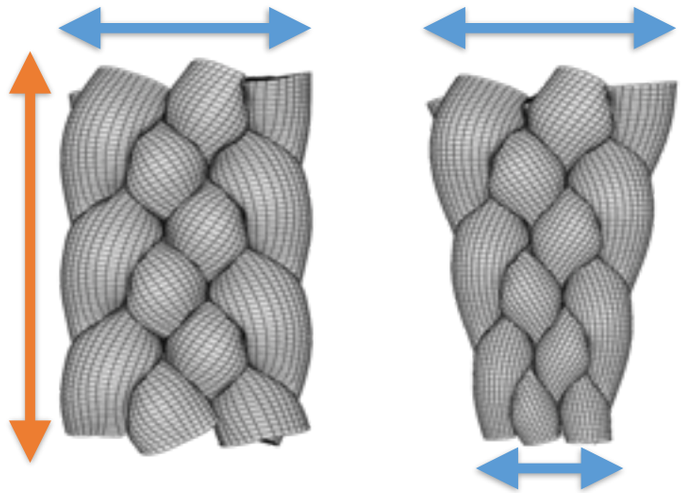
Five-strand
Dutch braid



Fishtail
braid

# Procedural Model





tail patch

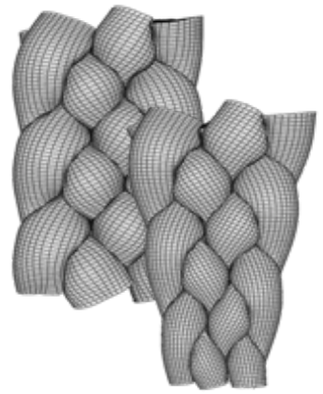
# Patch Fitting

Input photos

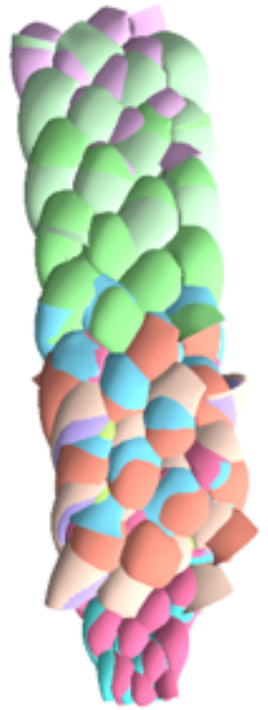
2D orientation maps

Input mesh

3D orientation field



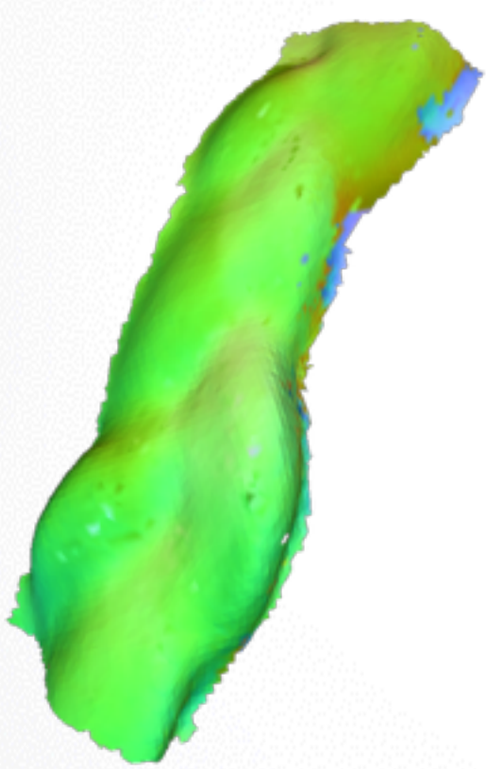
Database



Cleaned mesh

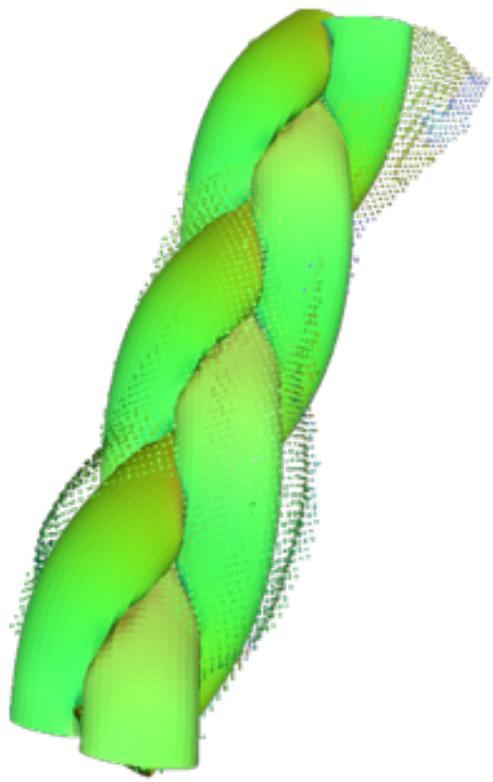
Fitting result

# Patch Fitting

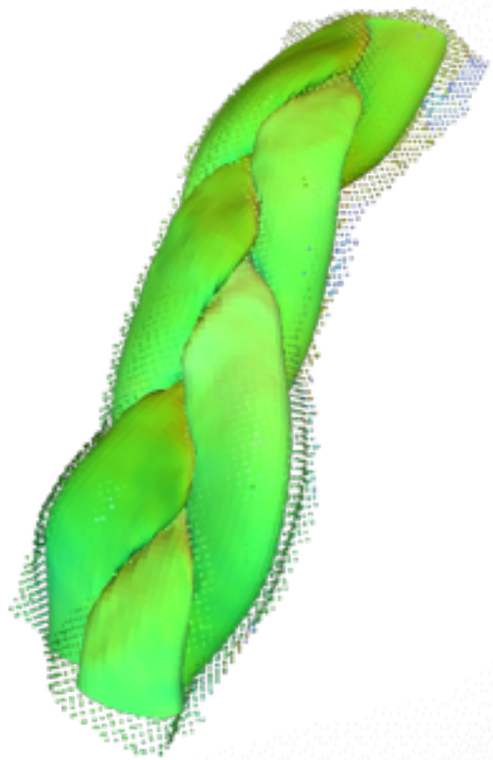


Input mesh $C$

Patch $P_f$

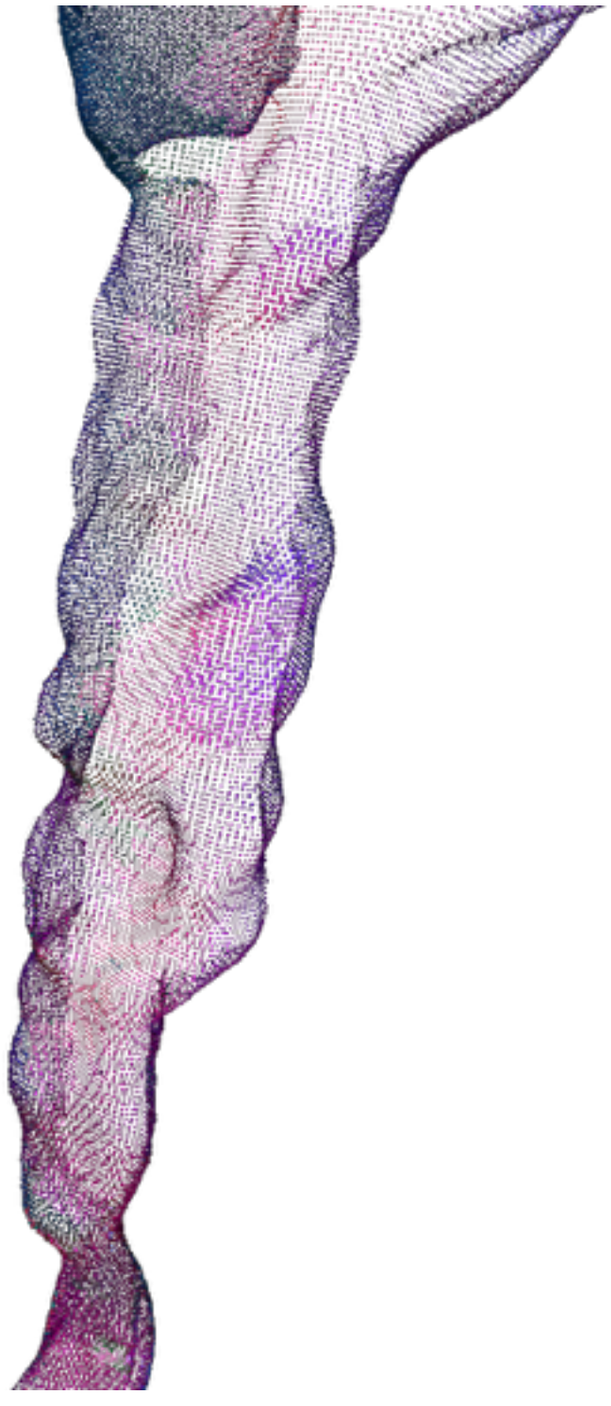


Rigid ICP

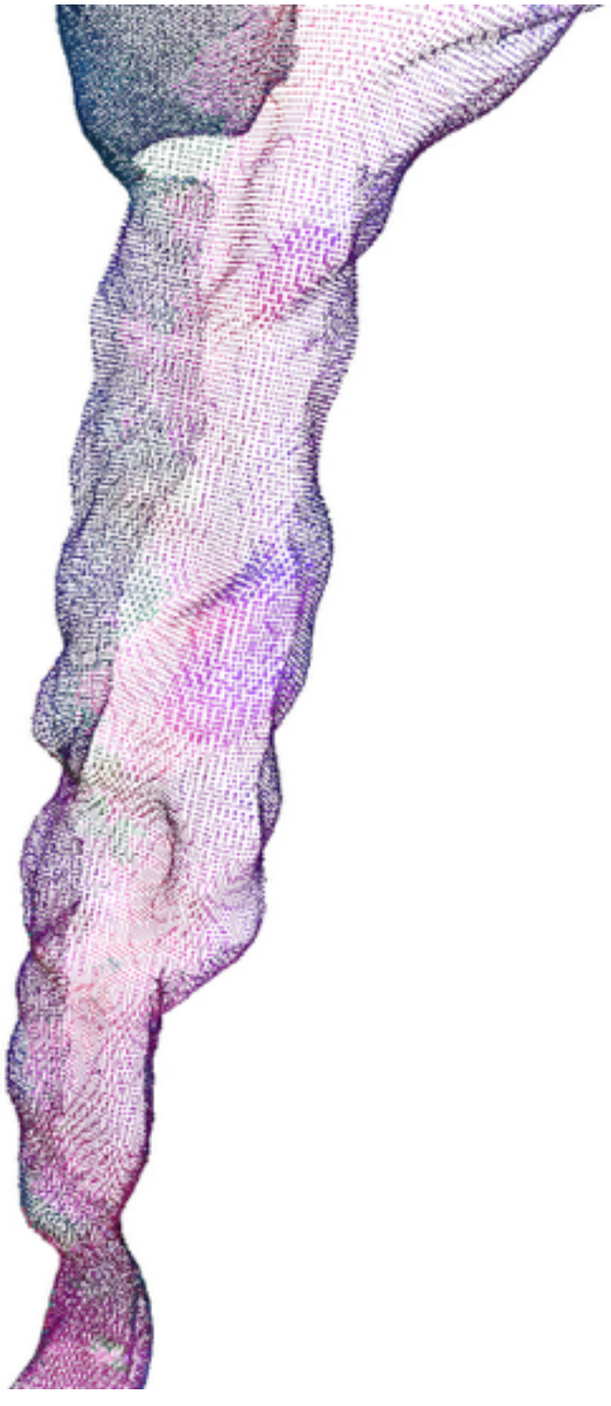


Non-rigid ICP
[Li et al. 2009]

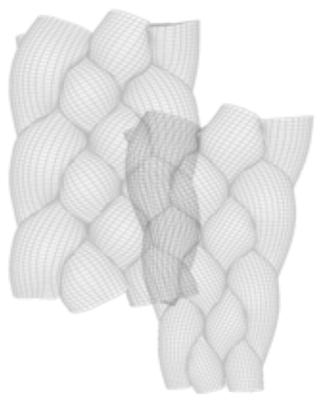
# Patch Fitting



Random sampling

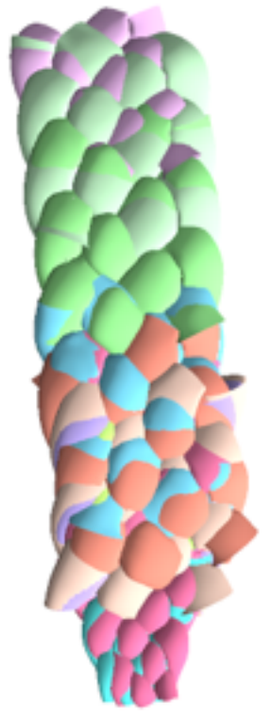


# Structure Analysis

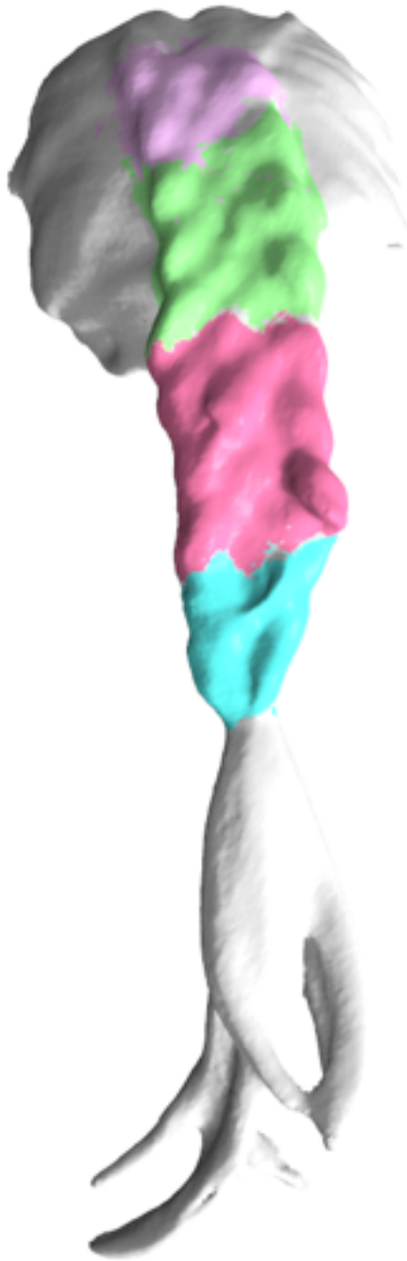


Database

Cleaned mesh



Fitting result

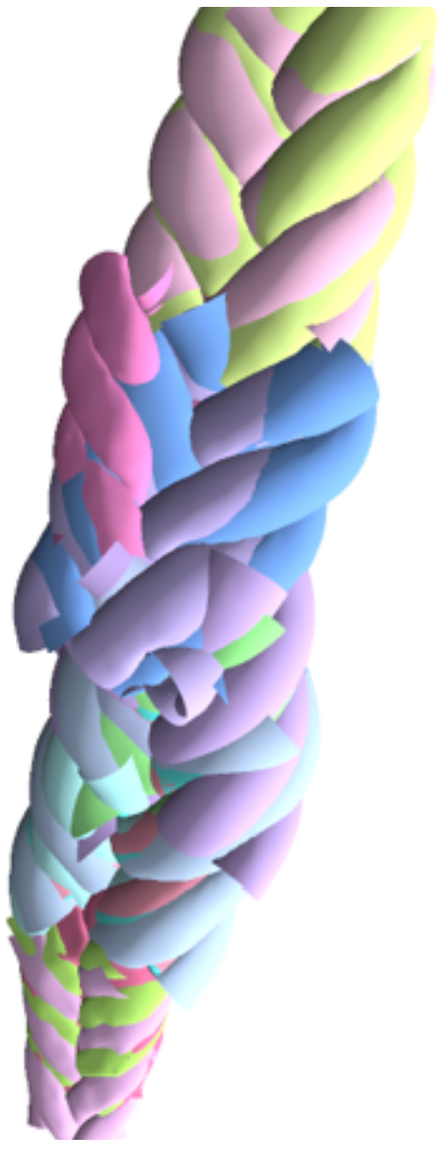


Labeling result

Extracted structure

# Structure Analysis

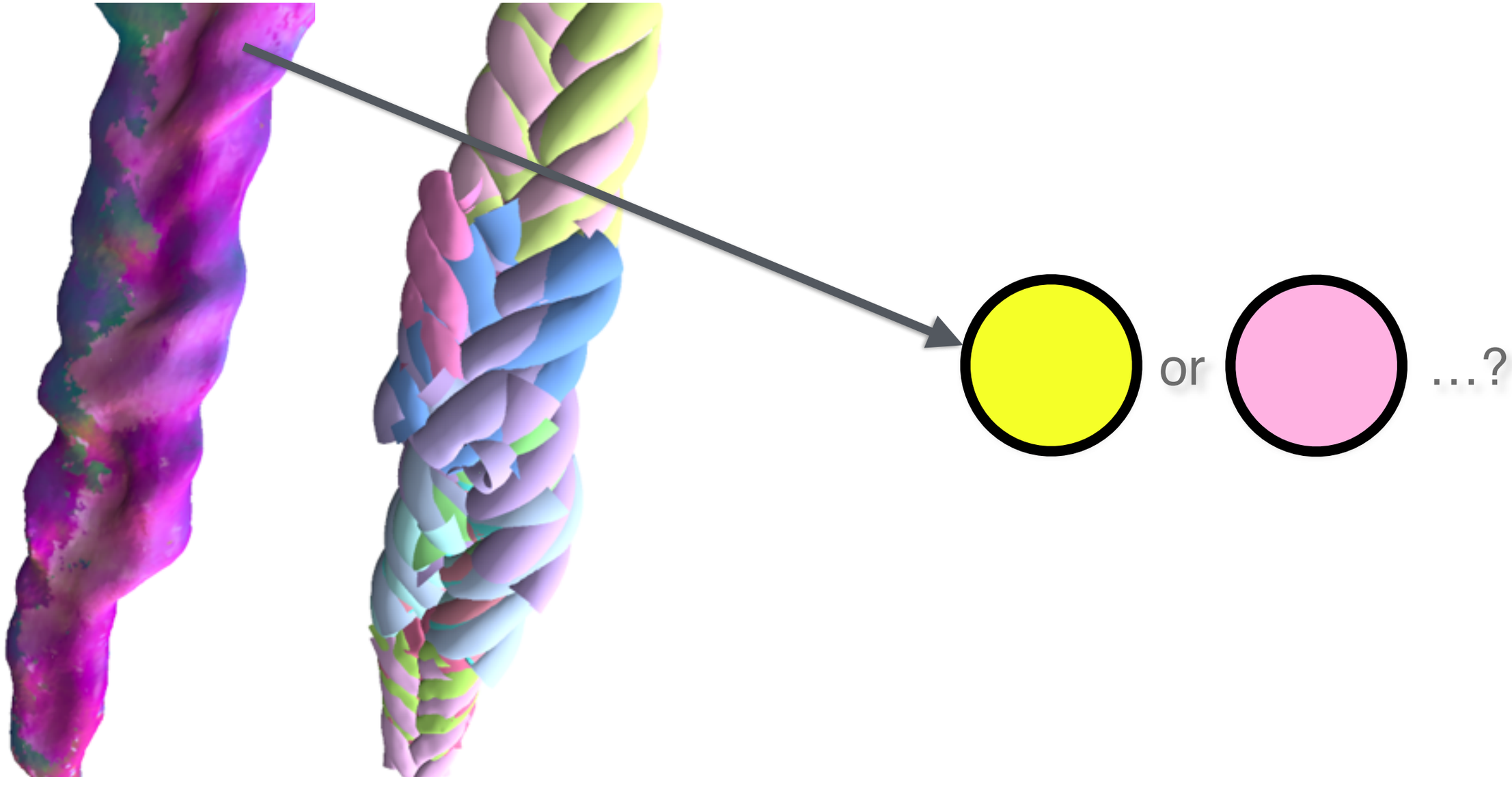
Input mesh



Candidate patches

# Structure Analysis

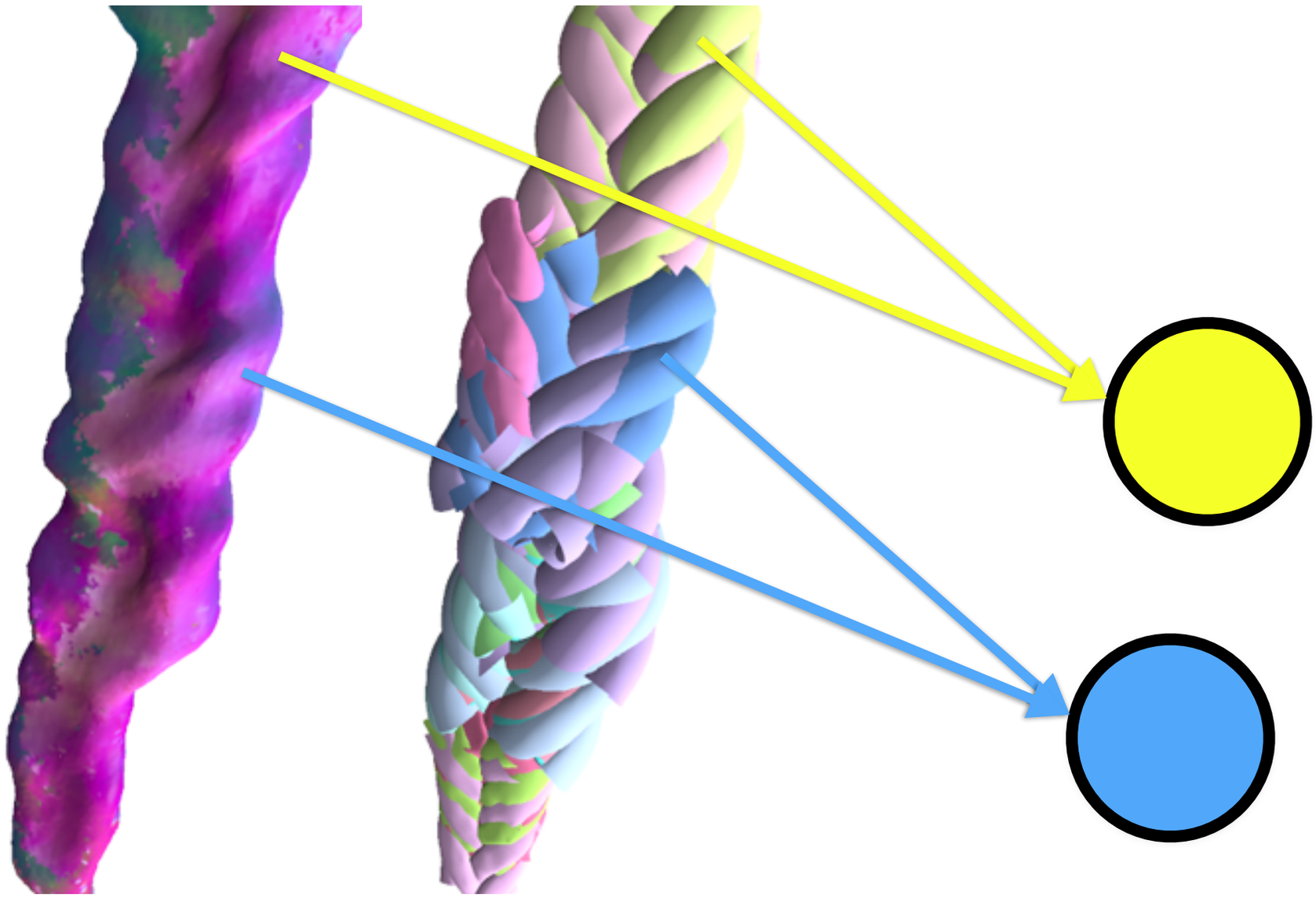
## Multi-label optimization




Input mesh  Candidate patches

# Structure Analysis

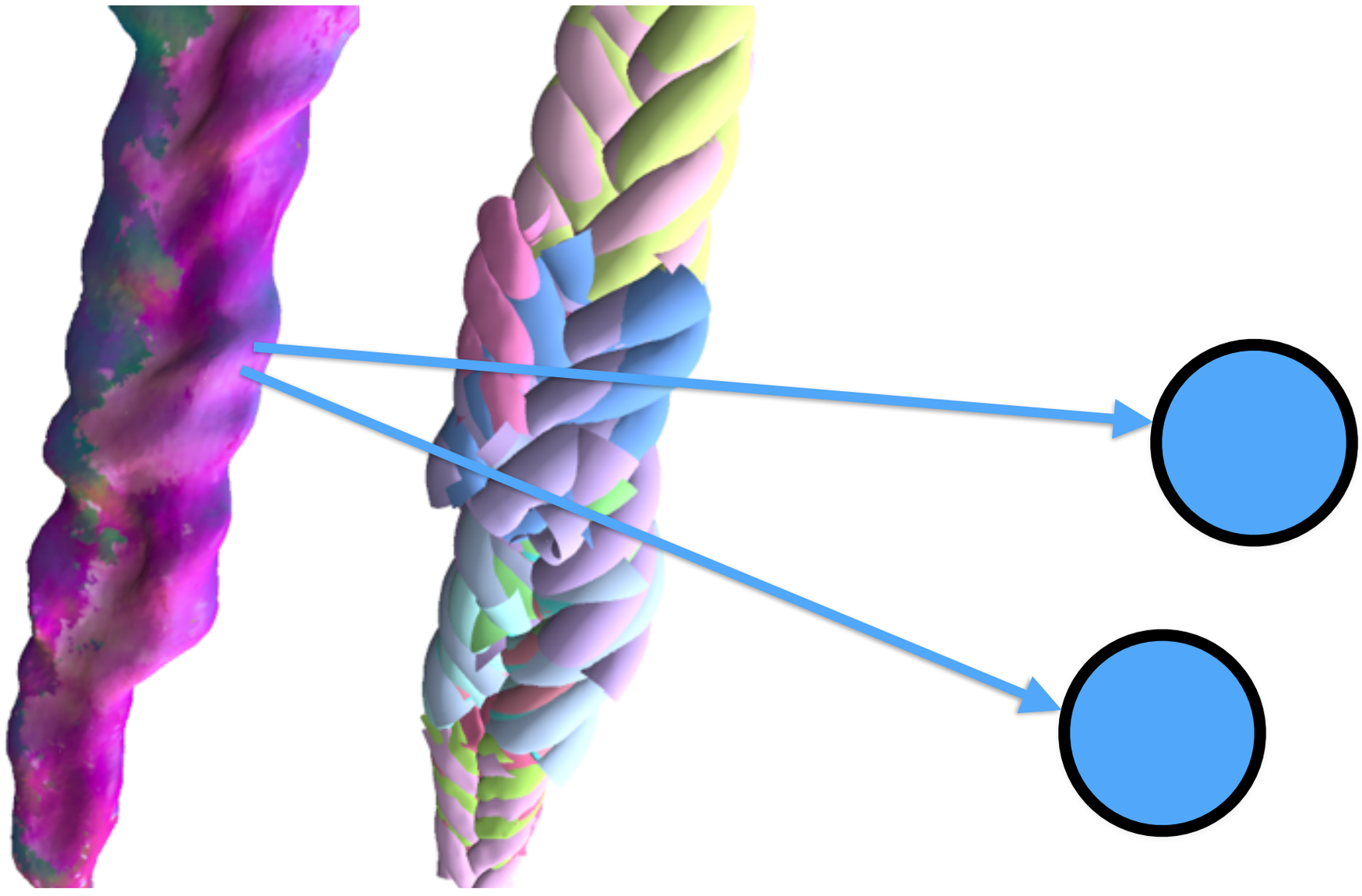
## Multi-label optimization



Input mesh  Candidate patches

# Structure Analysis

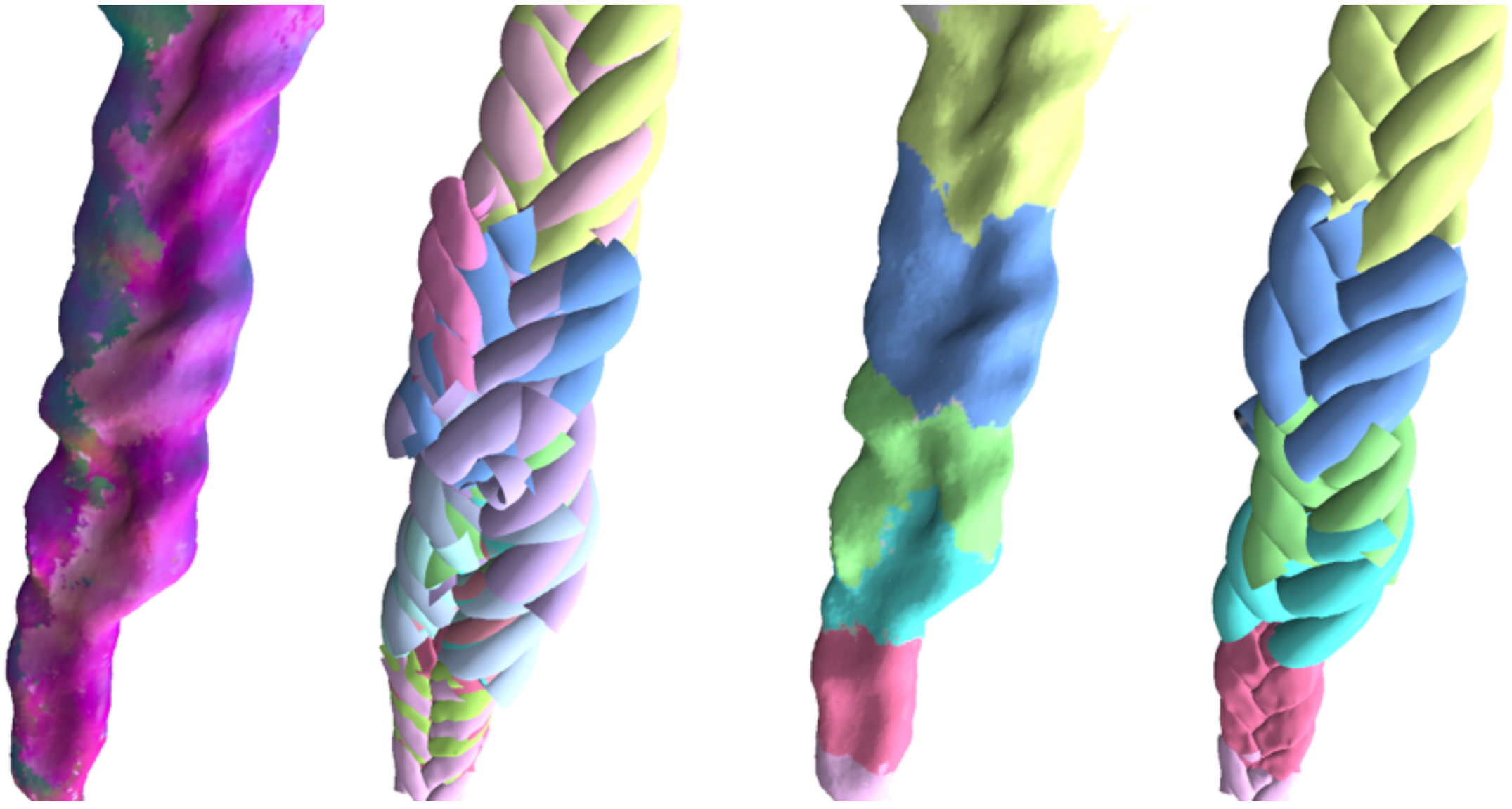
## Multi-label optimization



Input mesh  Candidate patches

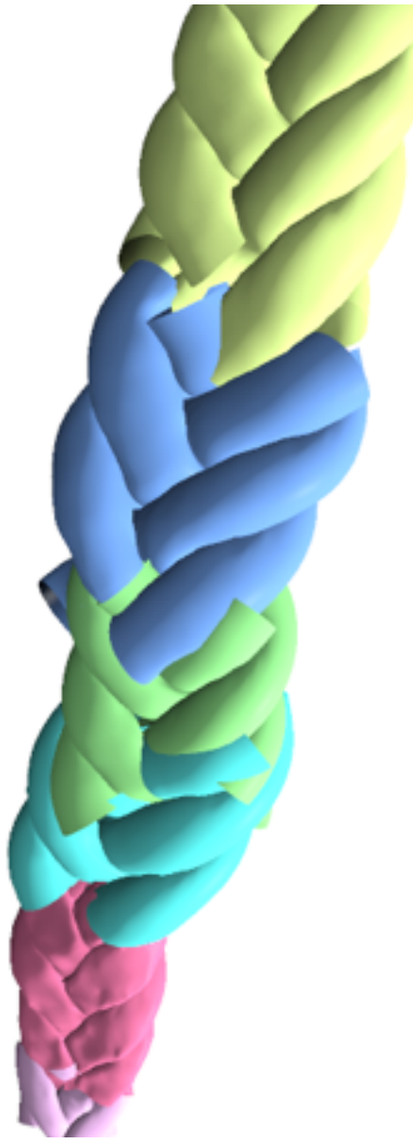
# Structure Analysis

## Multi-label optimization : Graph-cut [Delong et al. 2012]

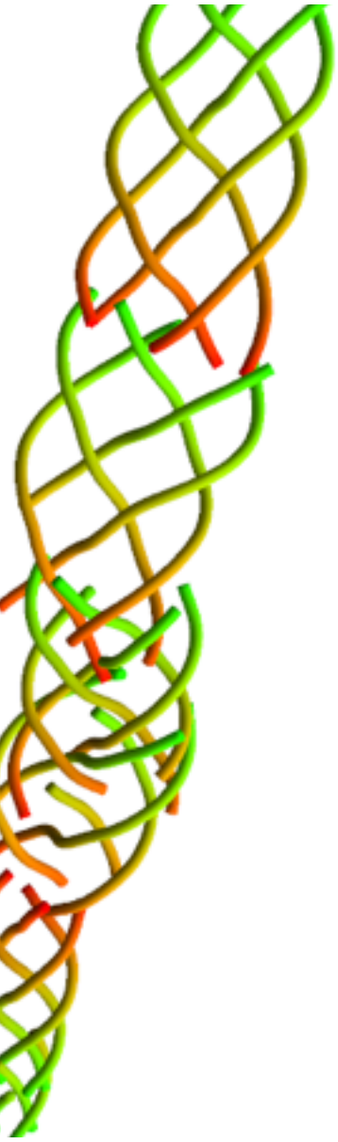


Input mesh | Candidate patches | Labeling result | Selected patches

# Structure Analysis

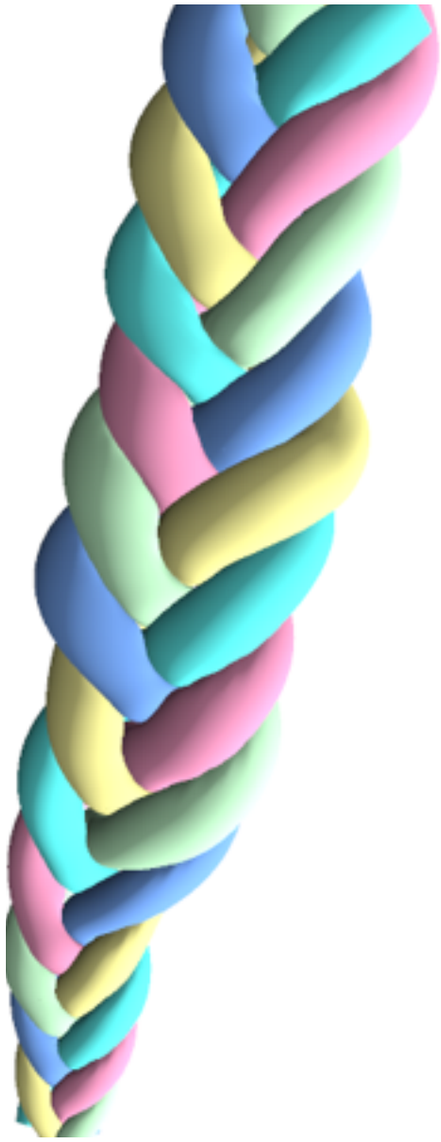


Selected patches

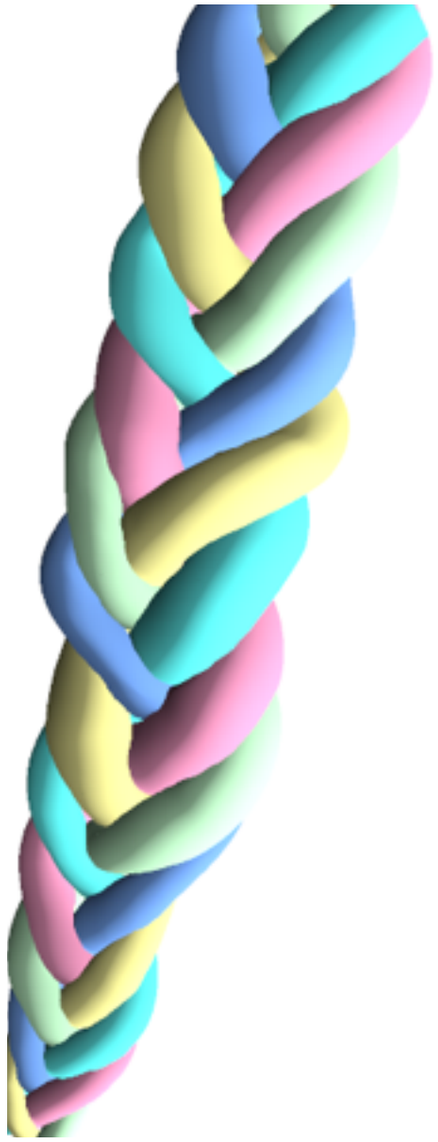


Extracted centerlines

Connected centerlines

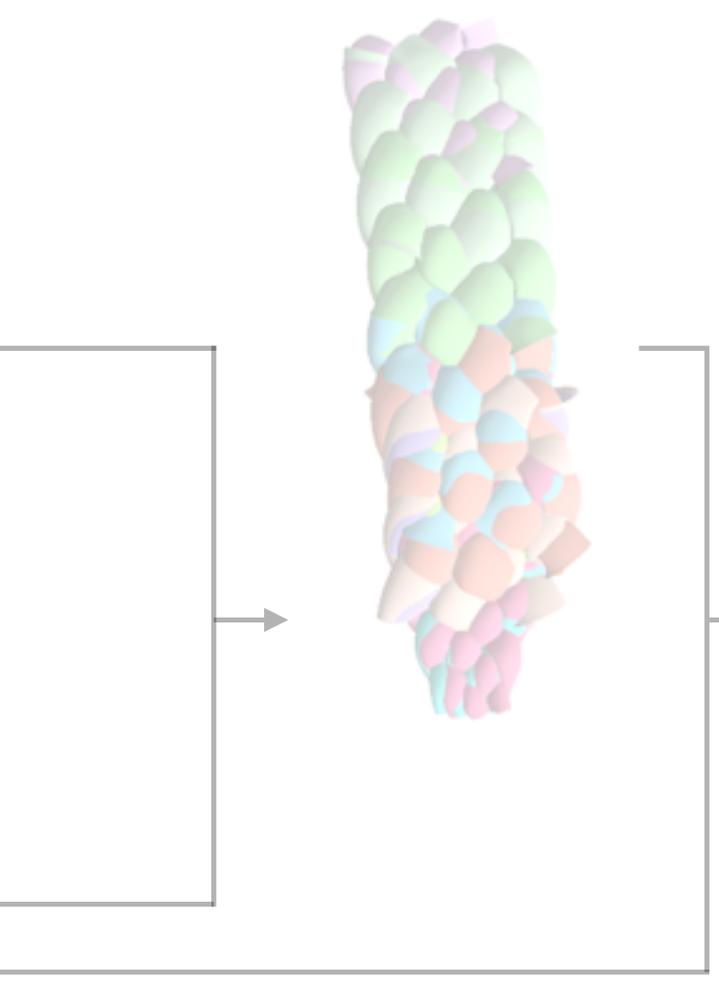


Expanded mesh



Refined result

# Strand Synthesis



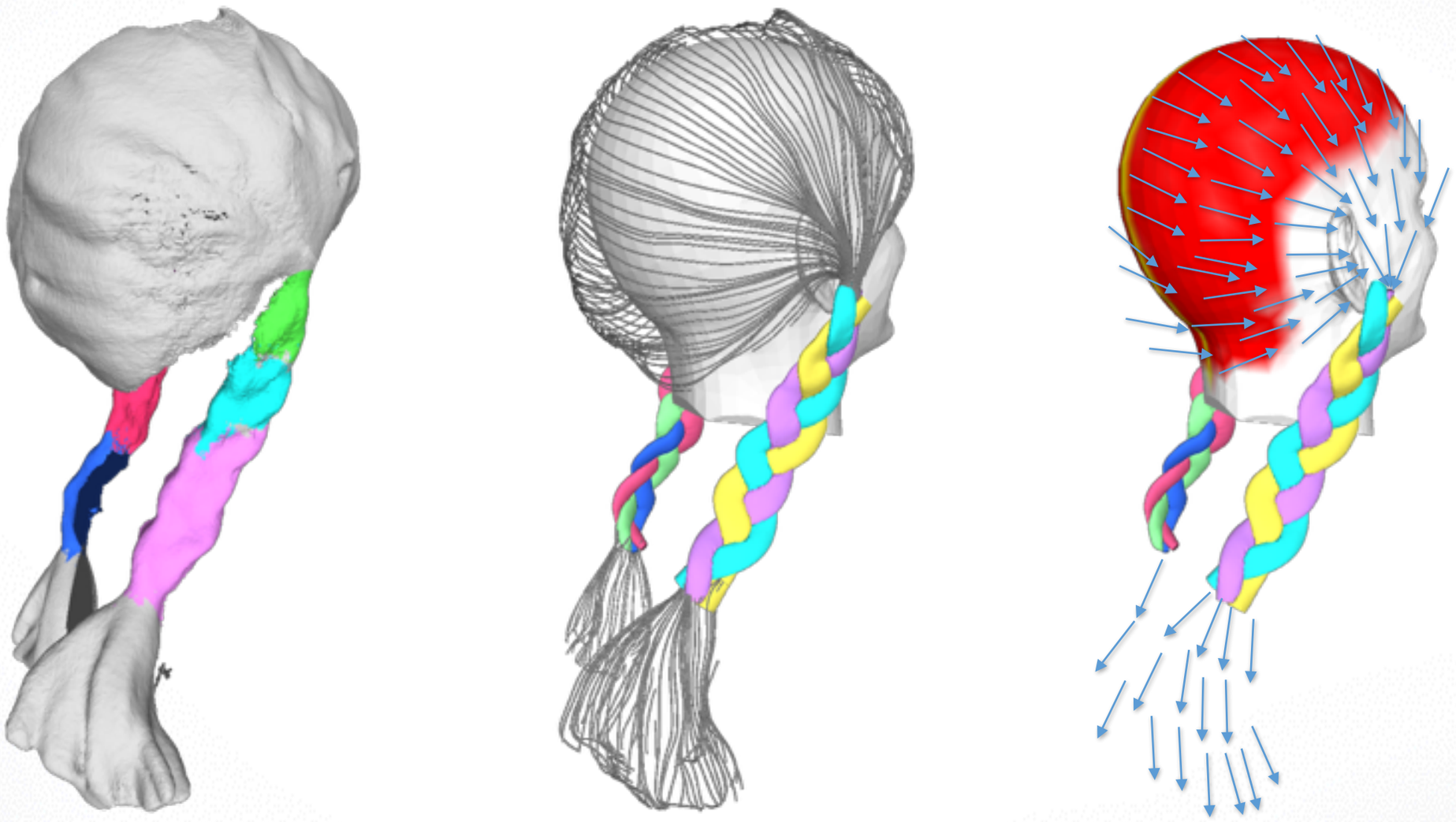
Fitting result

Labeling result

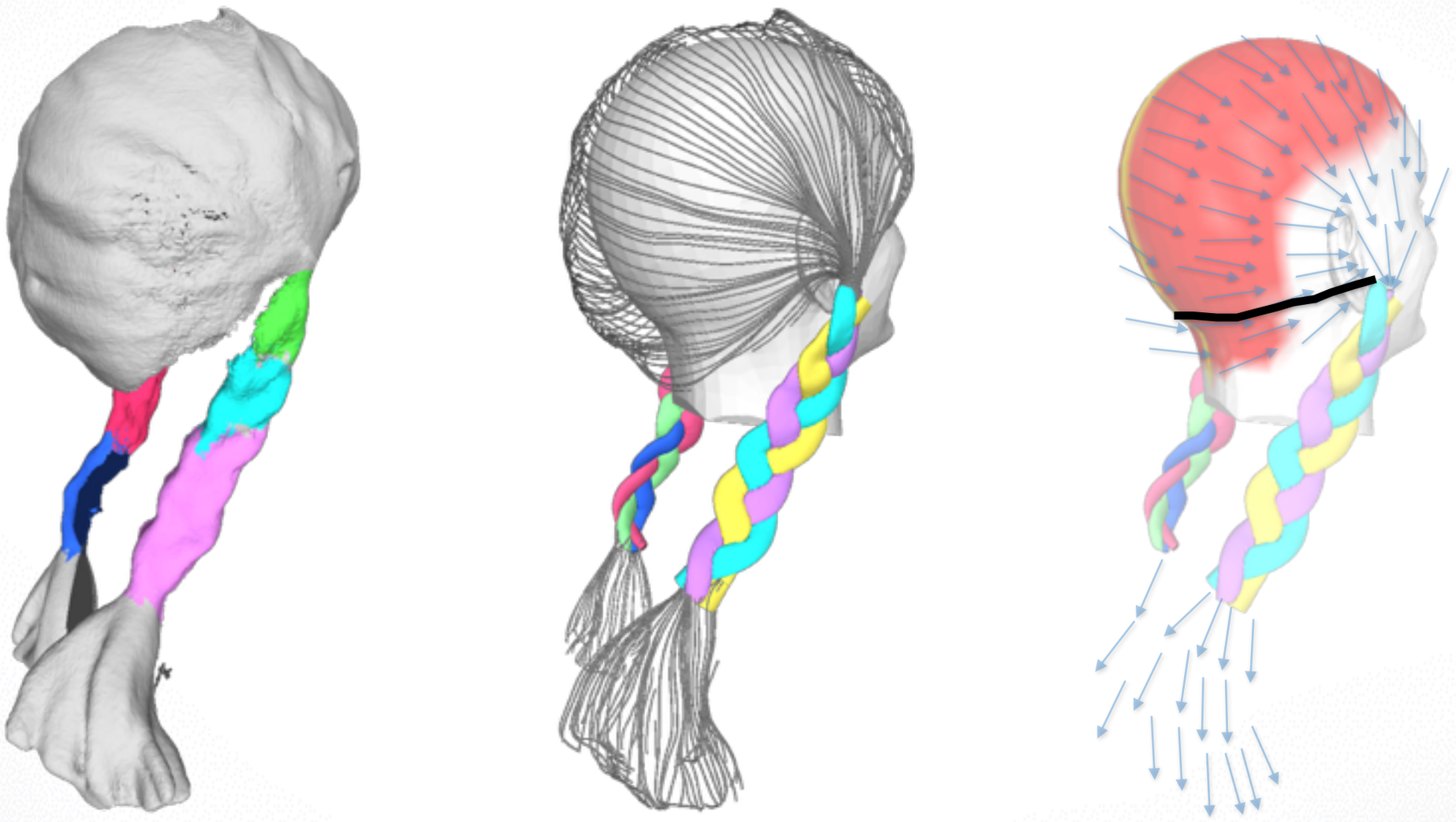
Extracted structure

Output strands

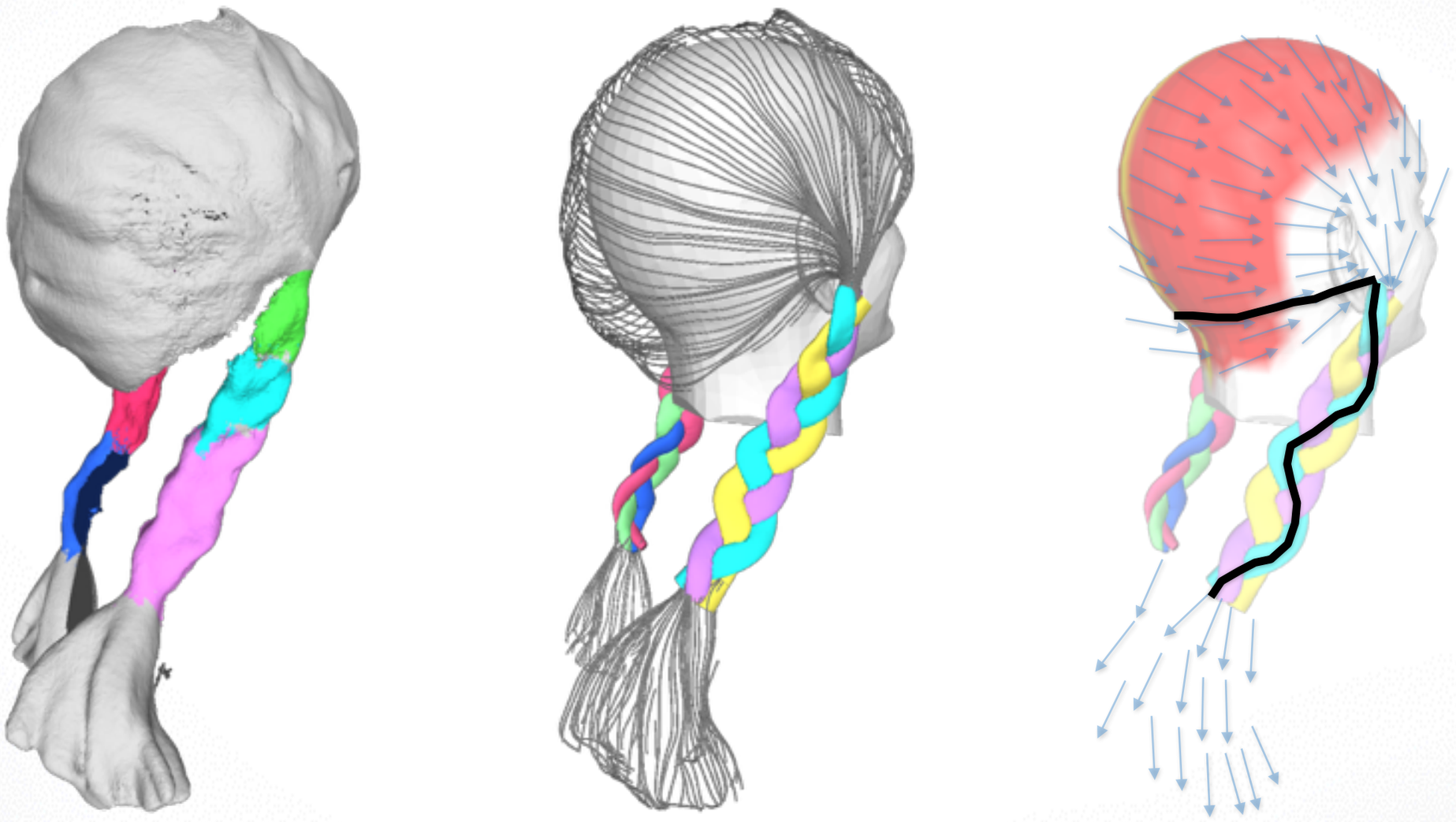
# Strand Synthesis



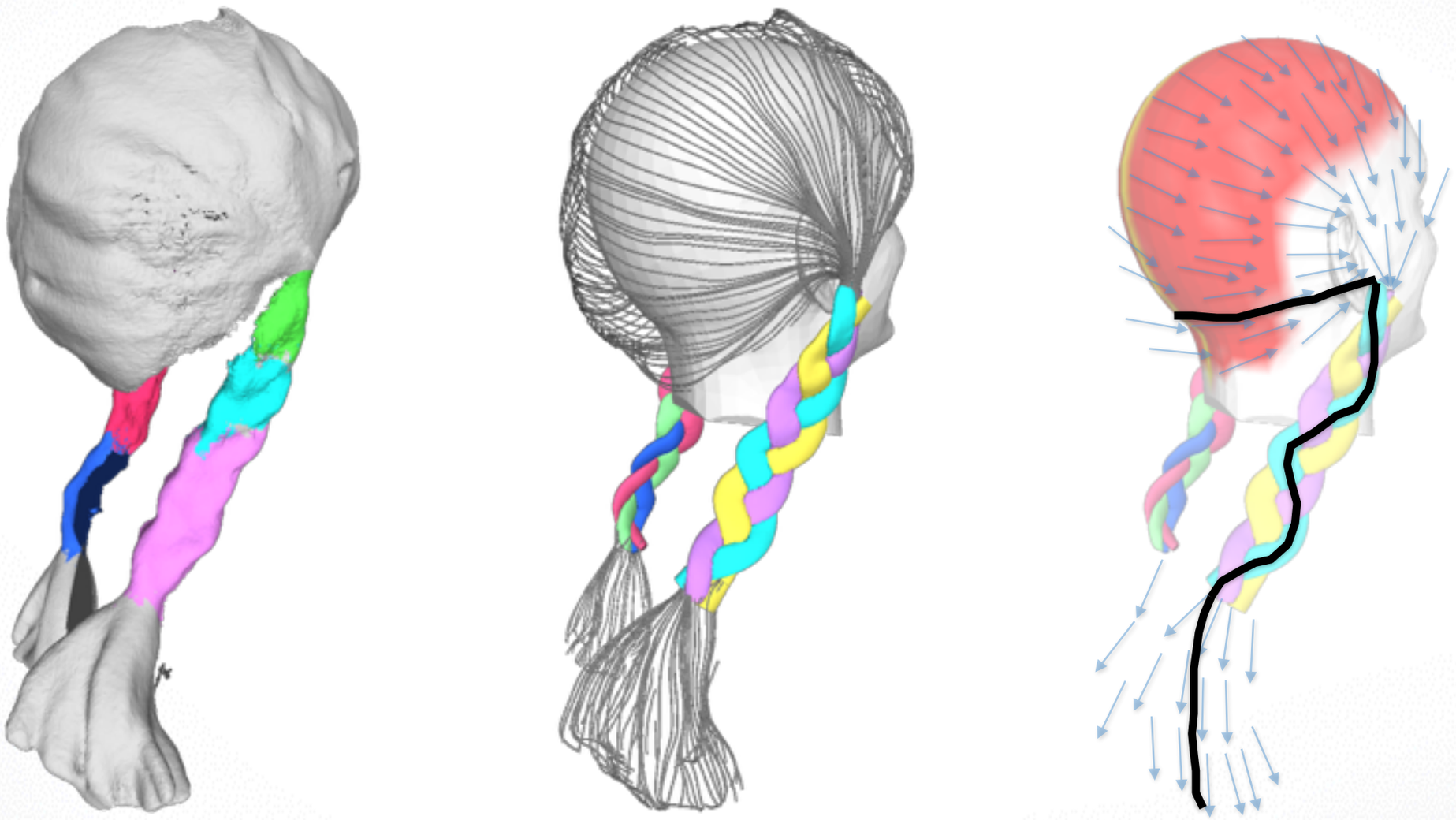
# Strand Synthesis



# Strand Synthesis



# Strand Synthesis



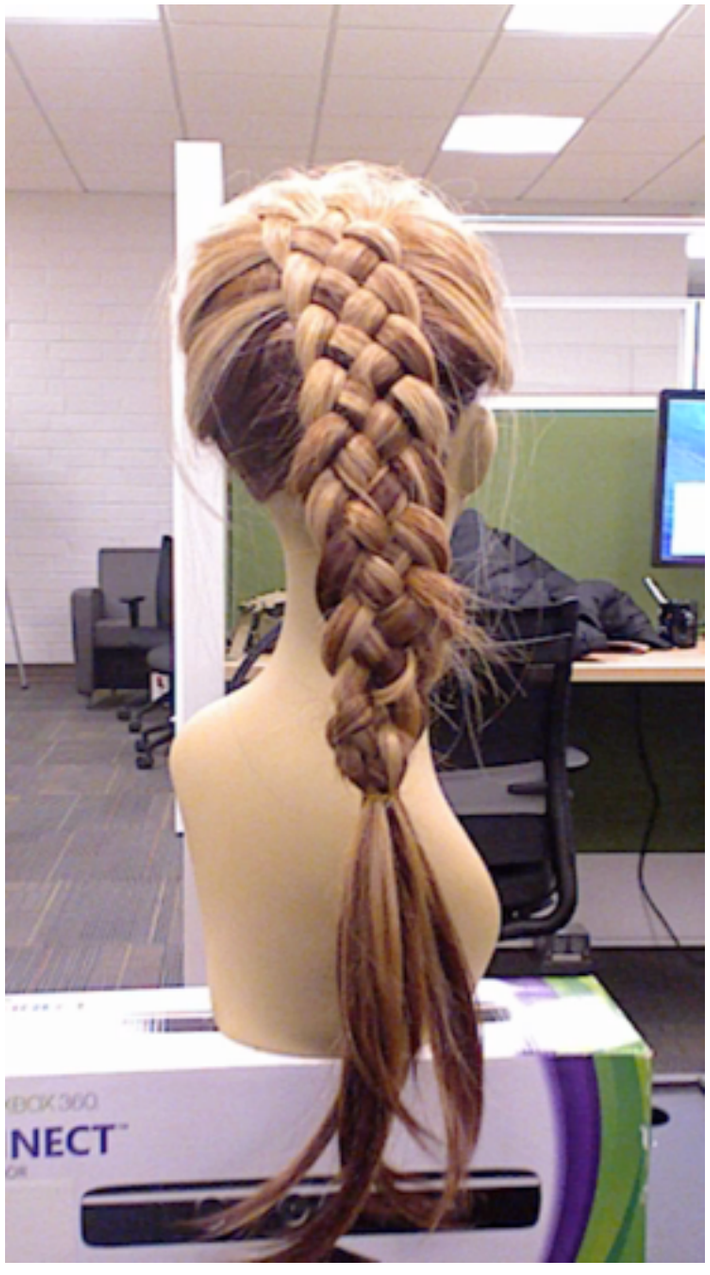
# Strand Synthesis

Perlin Noise for strand variation [Choe and Ko 2005]

Without fuzziness

With fuzziness

# Results: Five-strand Dutch Braid



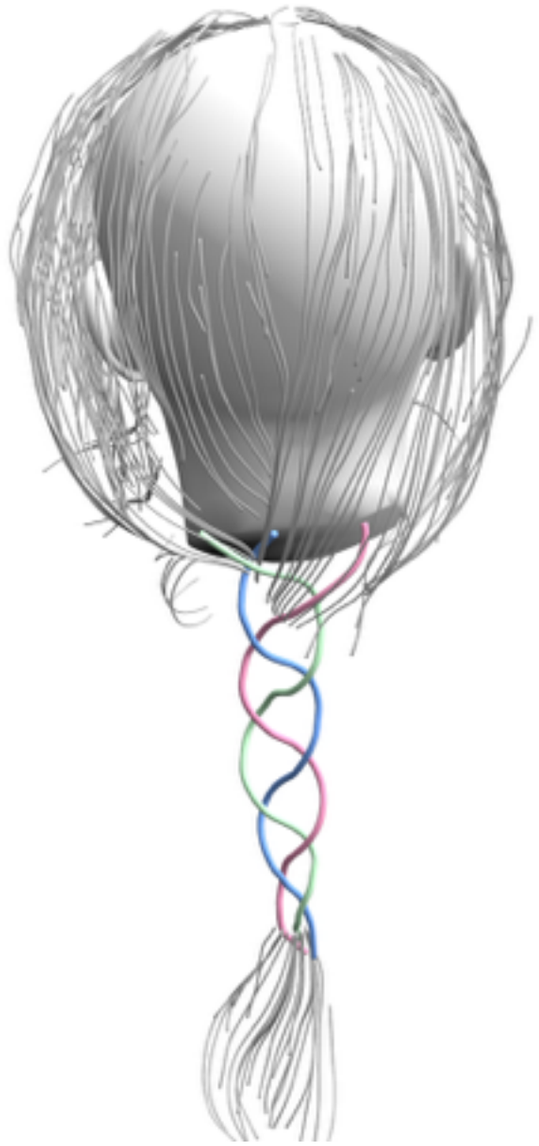

Reference photos

Extracted structure

Output strands

# Results: Basic Braid

Reference photos

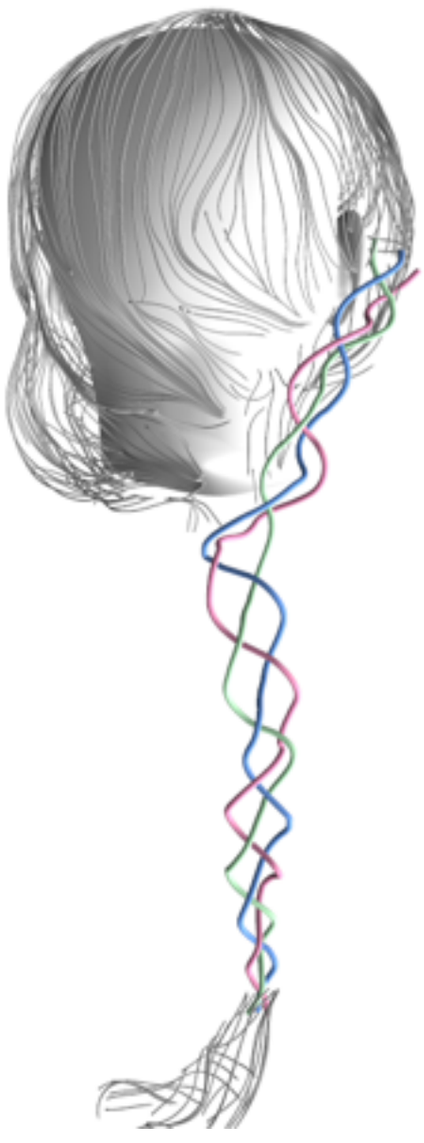


Extracted structure

Output strands

# Results: French Braid

Reference photos

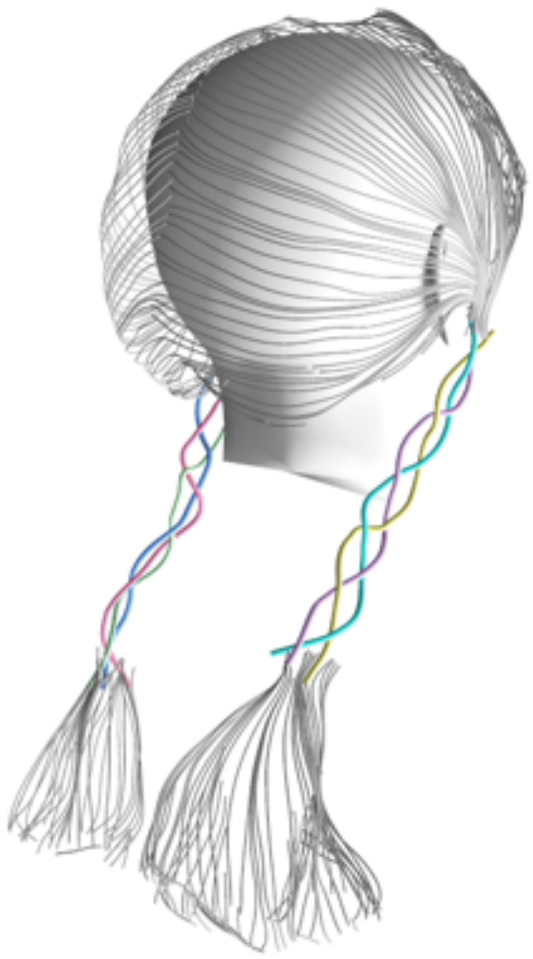


Extracted structure

Output strands

# Results: Two Basic Braids

Reference photos

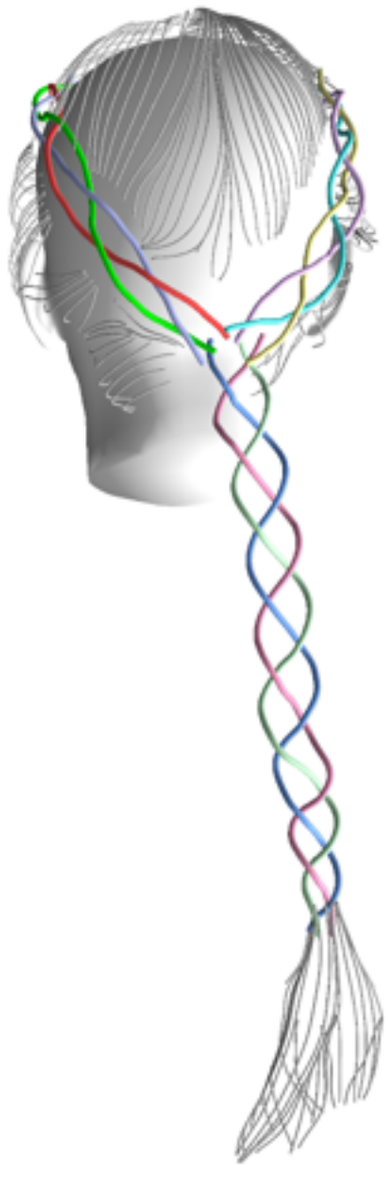


Extracted structure

Output strands

# Results: Princess Anne Braid

Reference photos

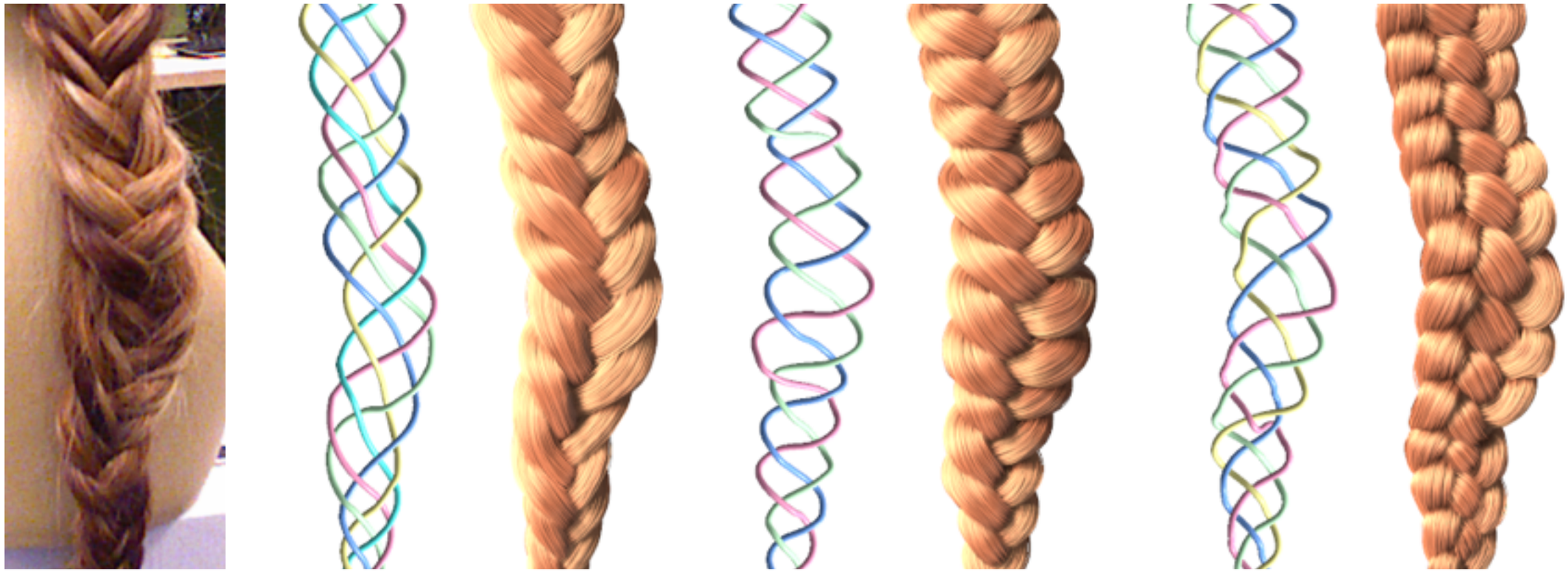


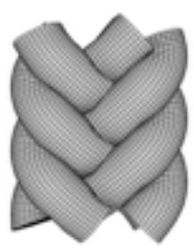
Extracted structure

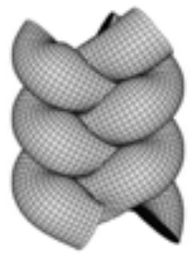
Output strands

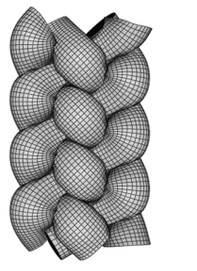
# Evaluation

## Different example patches









Reference photo

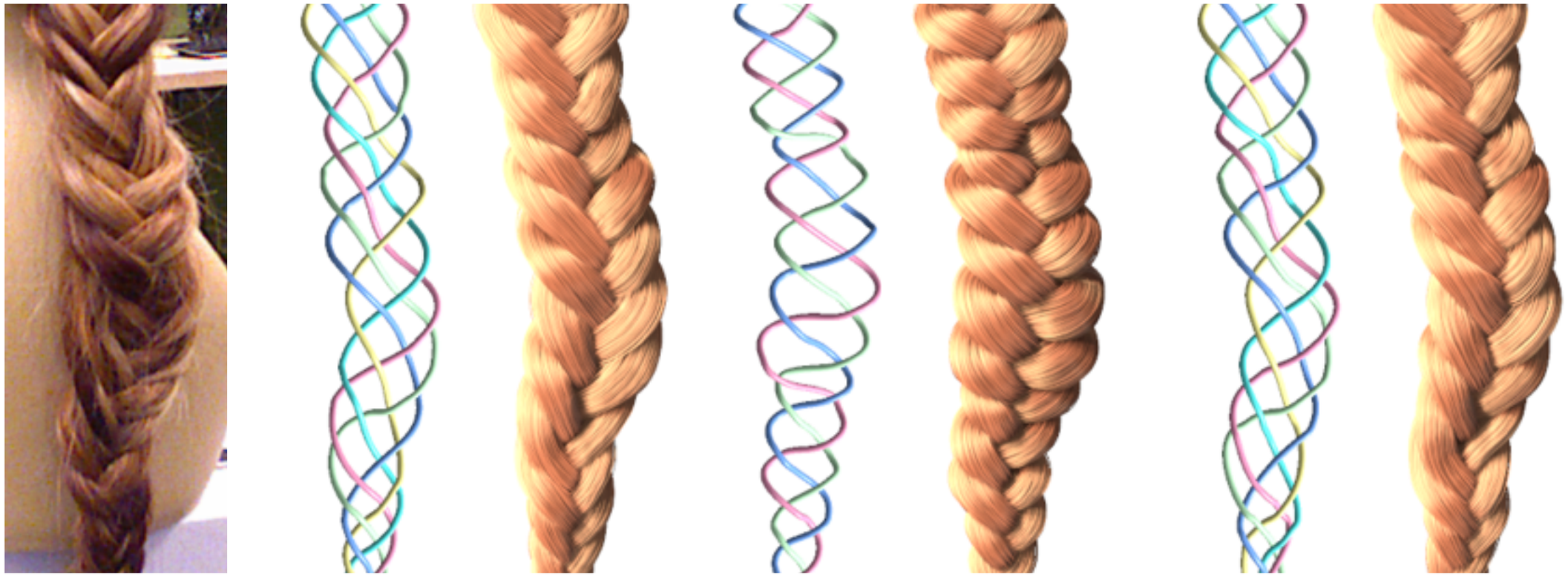
Fishtail
E = 66.86

3-strand
E = 87.09

4-strand
E = 98.52

# Evaluation

## Different example patches



Reference photo

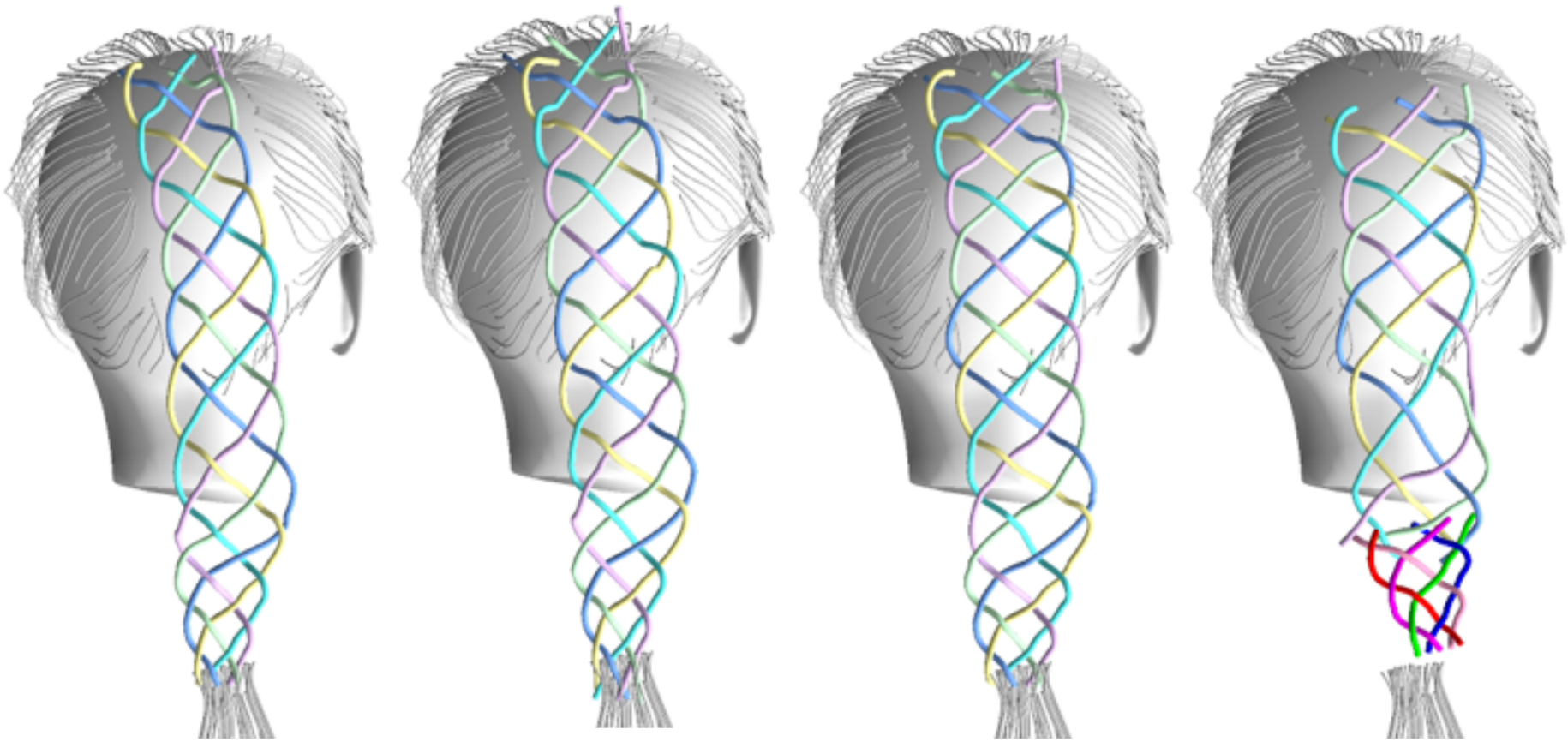
Fishtail
E = 66.86

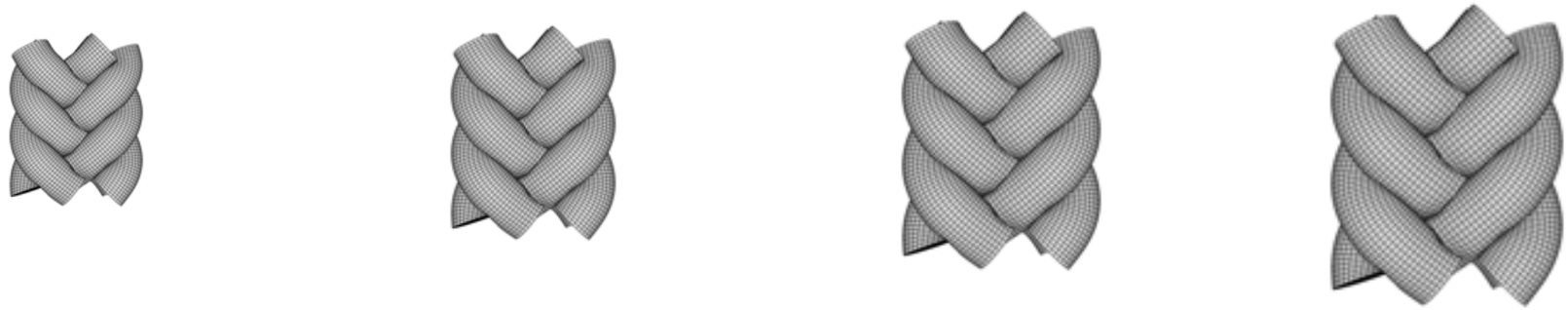
3-strand
E = 87.09

Fishtail & 3-strand
E = 68.36

# Evaluation

## Convergence on different initial scales of example patch





Reference photo

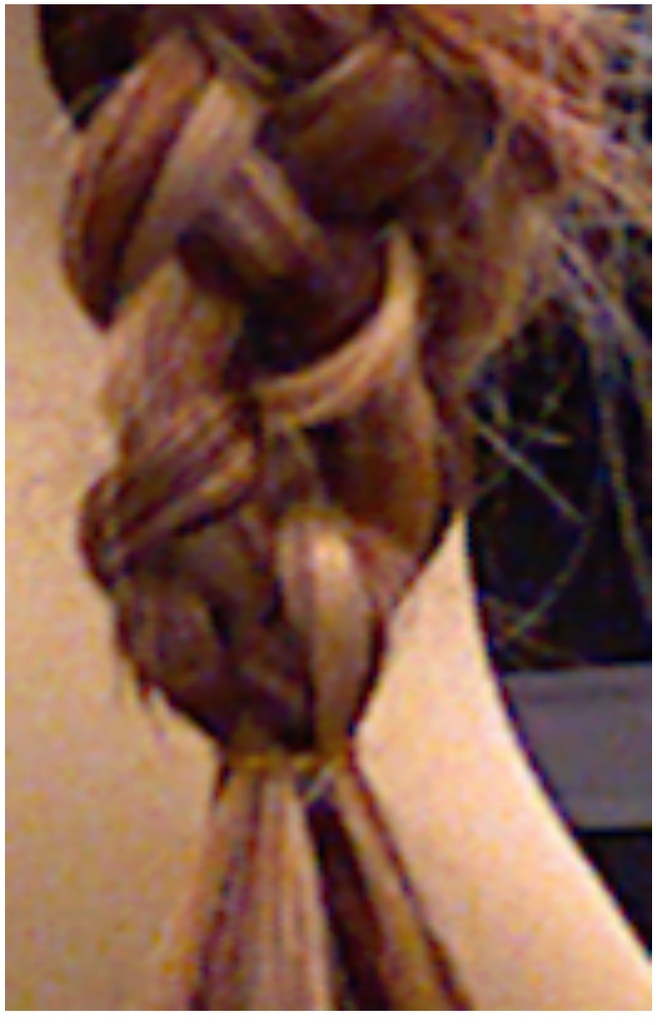
s = 0.8
E = 54.86

s = 1.0
E = 55.98

s = 1.2
E = 58.92

s = 1.3
E = 62.80

# Limitations

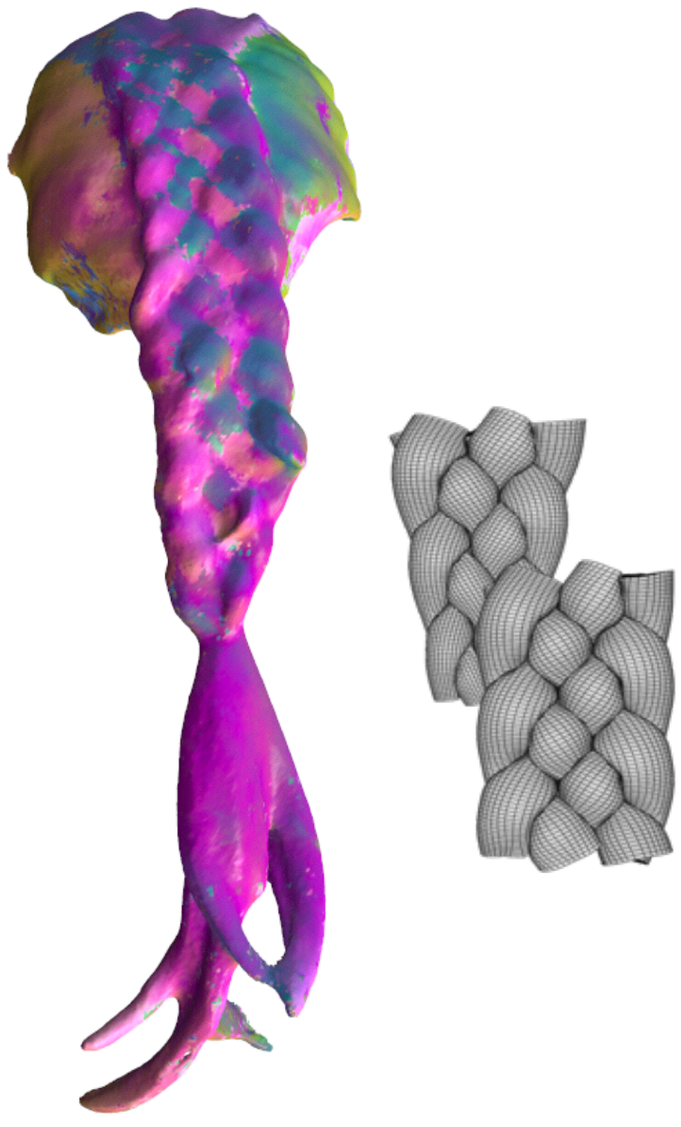


Reference photo

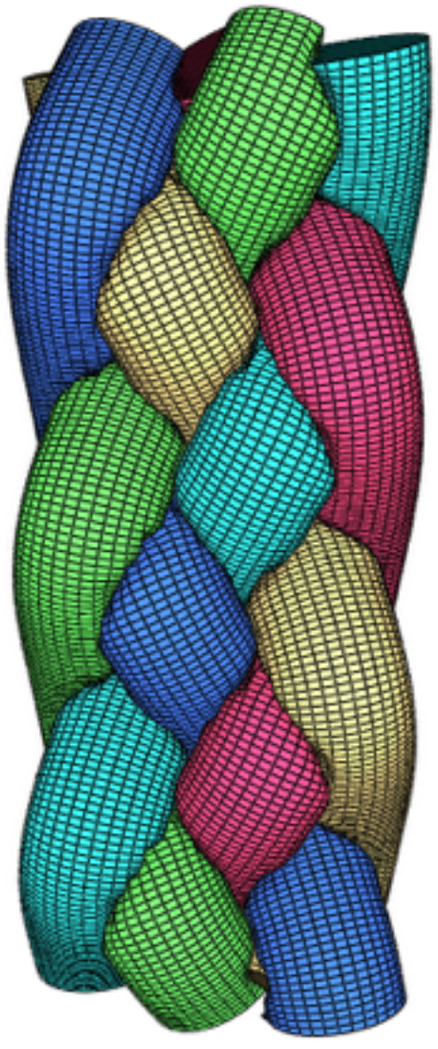
With tapering

Without tapering

# Summary



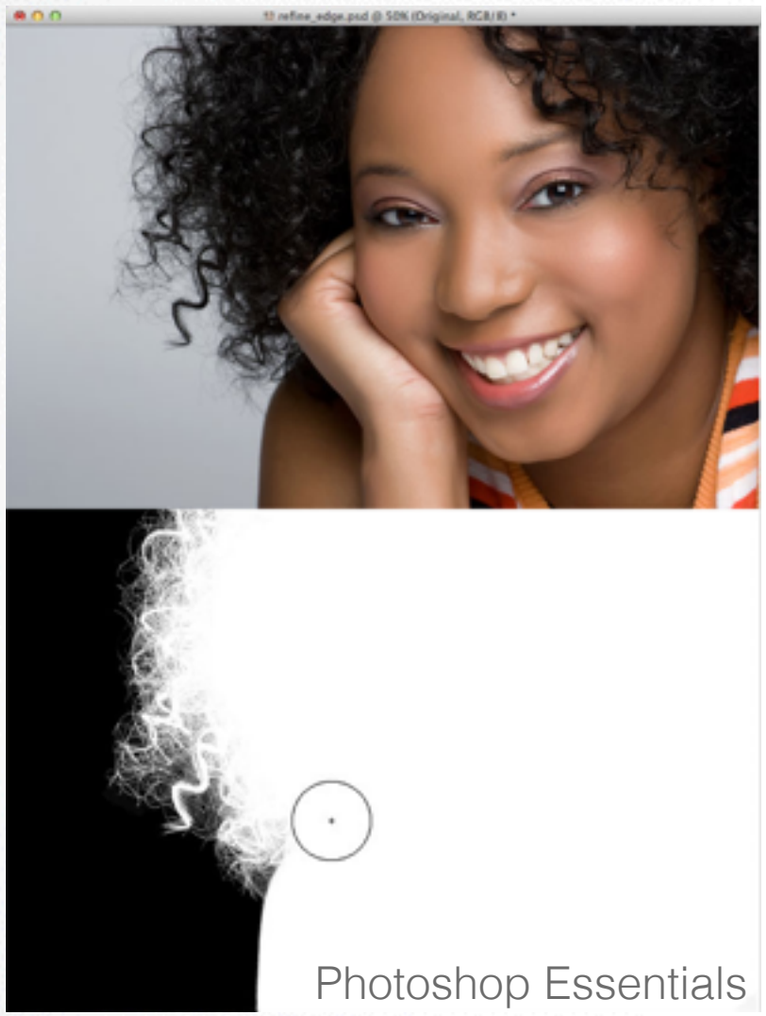
Data-driven framework



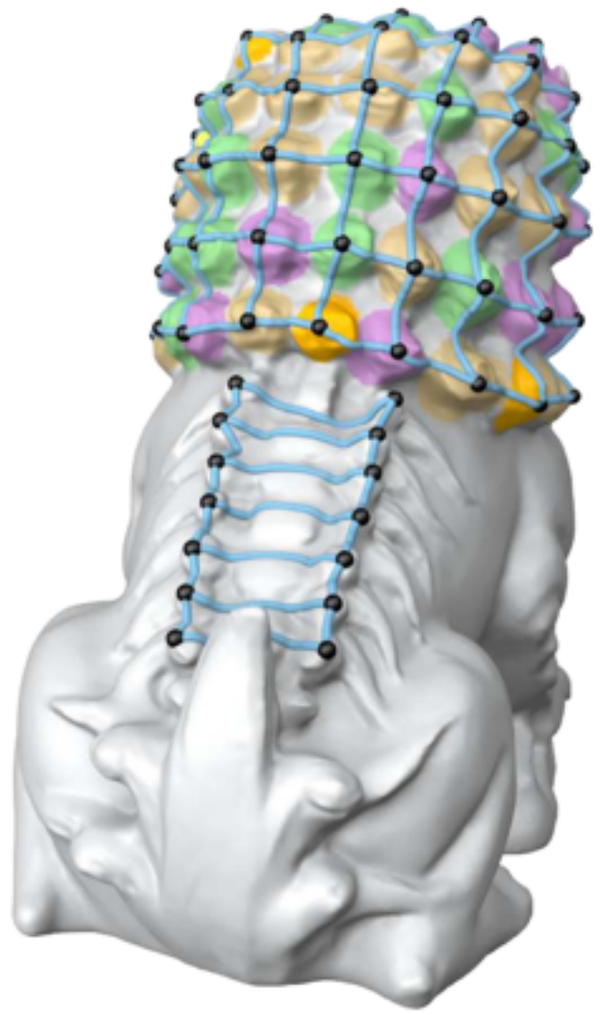
Procedural braid models

Patch-based analysis algorithm

# Future work




Hair segmentation



Scale extraction
[Huang et al. 2014]


More complex
structures

# Acknowledgements

Anonymous reviewers

**Capture models**

Frances Chen, Iris Wu, and Kirsty Lingman

**Rendering**

Szymon Rusinkiewicz

**Multi-view stereo data**

Ecco Studios

**Proofreading**

Kyle Olszewski and Jessica Rossky

**Funding**

USC IMSC, HKU 717112E, Adobe Systems,
Intel, NVIDIA, and Pelican Imaging

# Thank you!