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Robust Hair Capture Using Simulated Examples

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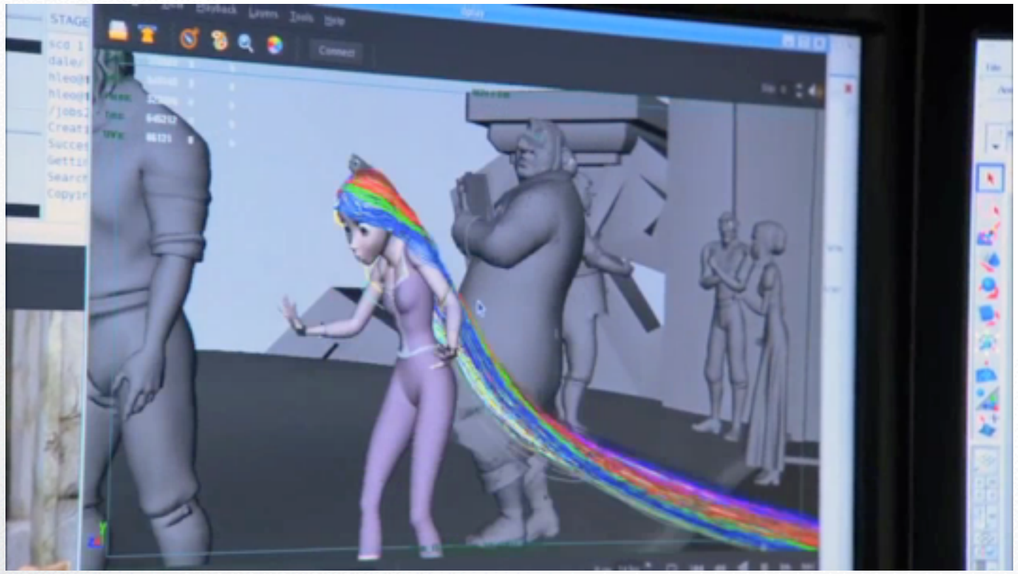
[1]University of Southern California [2]Adobe Research

Introduction

Introduction

Nvidia

Square Enix Inc.



Disney

Pixar

Complexity

Specularity

Image credit: LUX

Diversity

Image credit: TAAZ

Related Work: Hair Modeling

[Kim et al. 2002]

[Yuksel et al. 2009]

[Wang et al. 2009]

[Chai et al. 2013]

Related Work: Hair Capture

[Paris et al. 2004]

[Wei et al. 2005]

[Paris et al. 2008]

[Jakob et al. 2008]

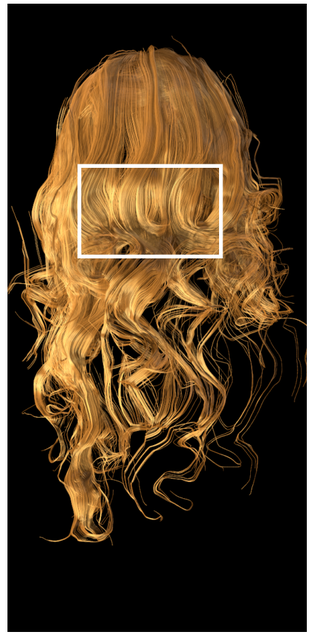
[Beeler et al. 2012]

[Luo et al. 2013]

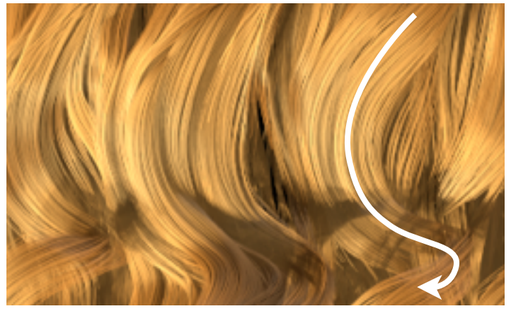
[Echevarria et al. 2014]

Motivation

Reference photo & point cloud



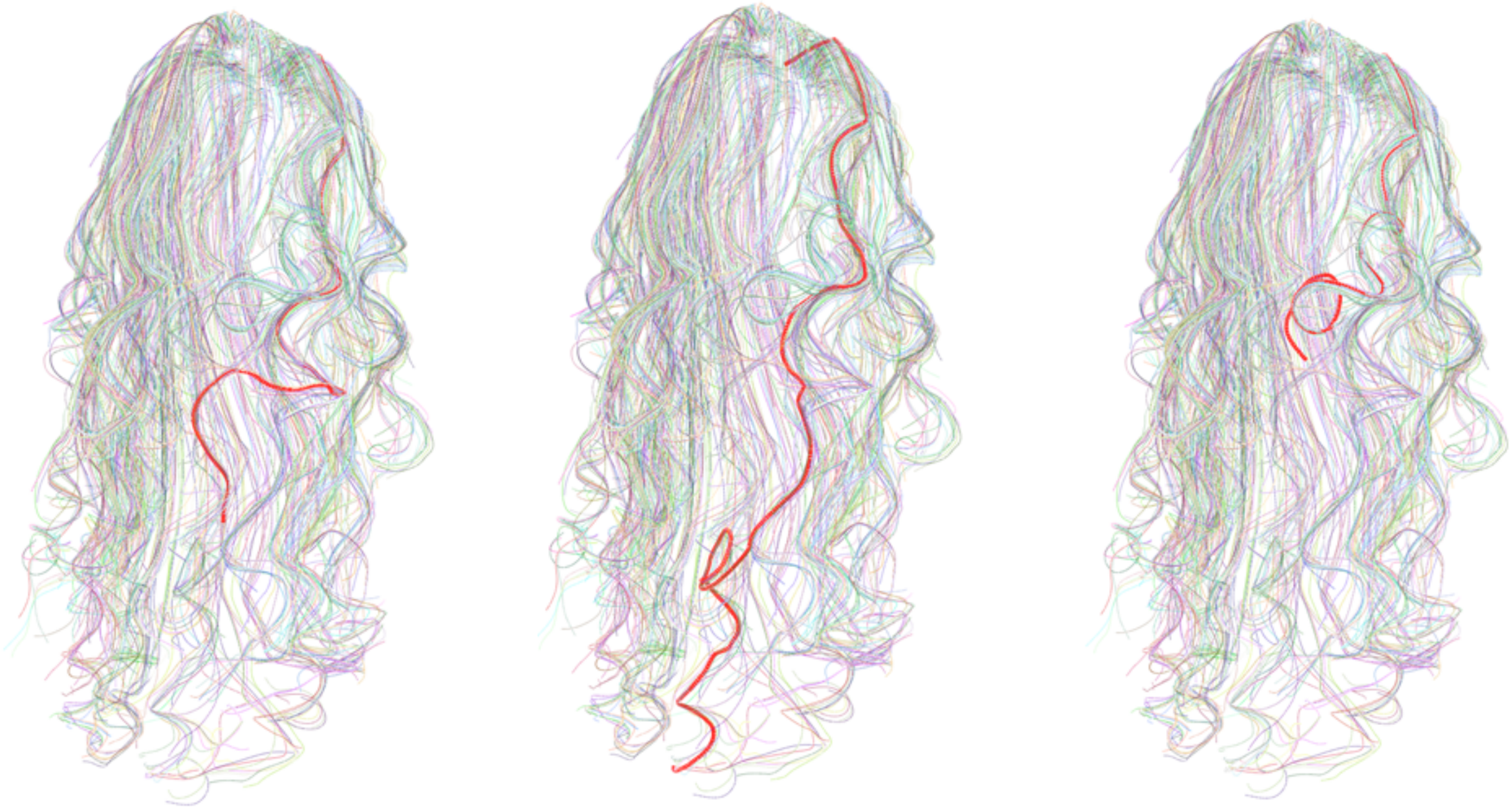
[Paris et al. 2008]



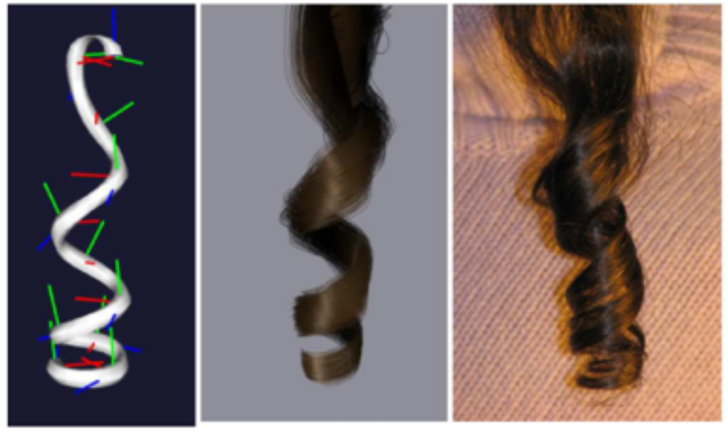
[Luo et al. 2013]

Motivation

Implausible structures in the output [Luo et al. 2013]

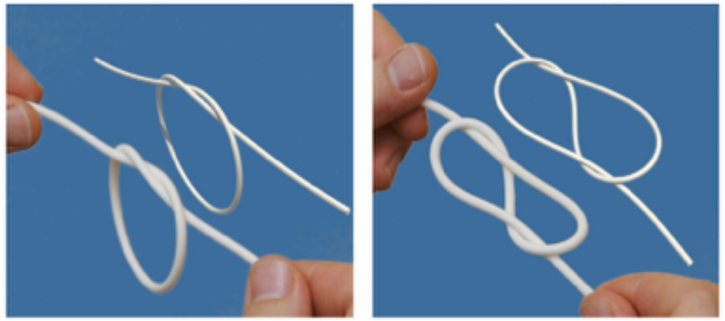


Related Work: Hair Simulation



[Bertails et al. 2005]

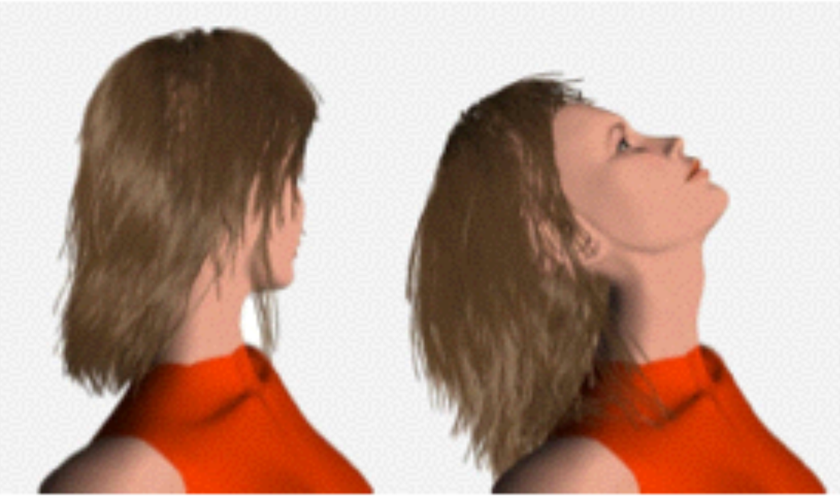
[Bertails et al. 2006]



[Bergou et al. 2008]

[Hadap et al. 2005]

[Selle et al. 2005]



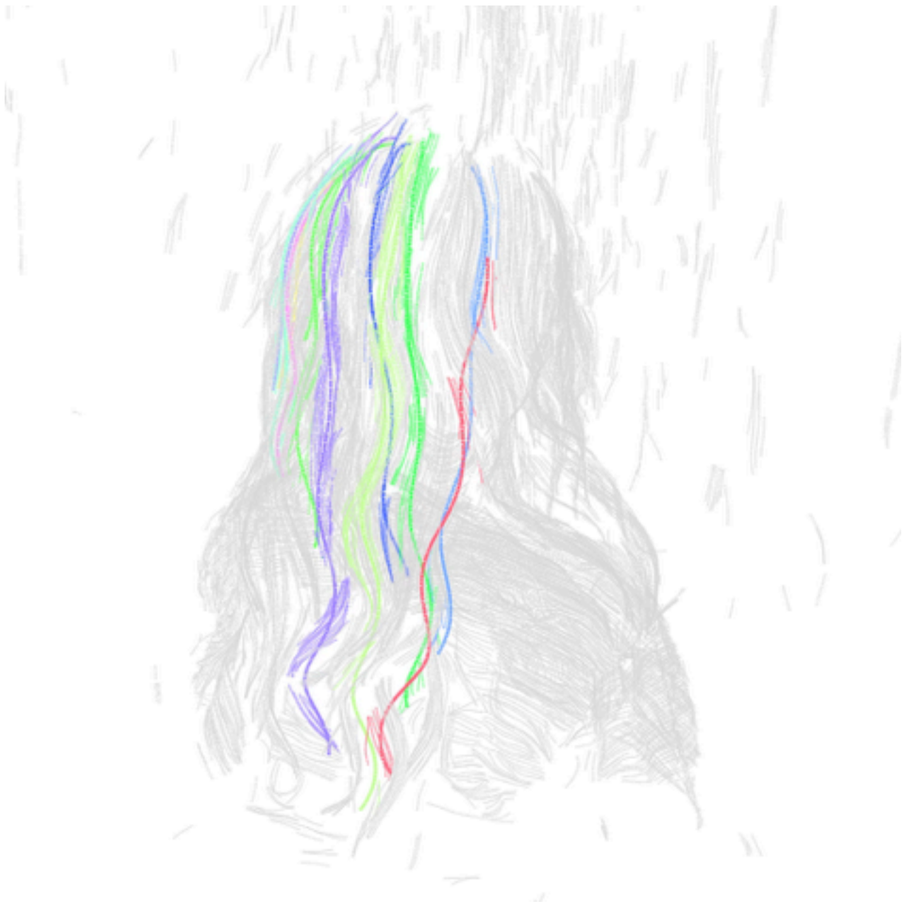
[Derouet et al. 2013]

Motivation

Tedious manual clean-up of outliers

Key Idea

Database of plausible strands as structure reference

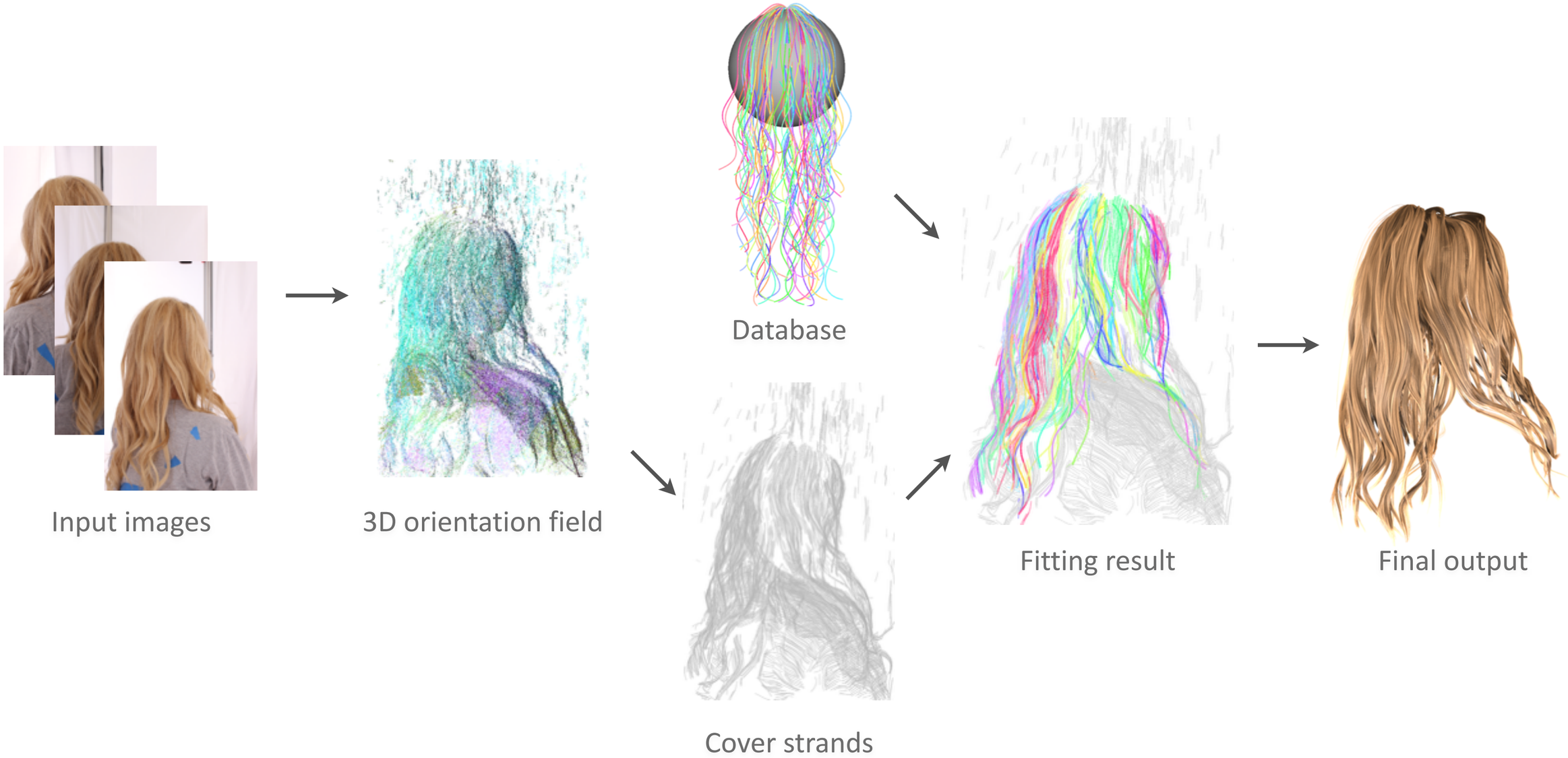


Cover strands

Simulated examples

Reconstruction result

Overview

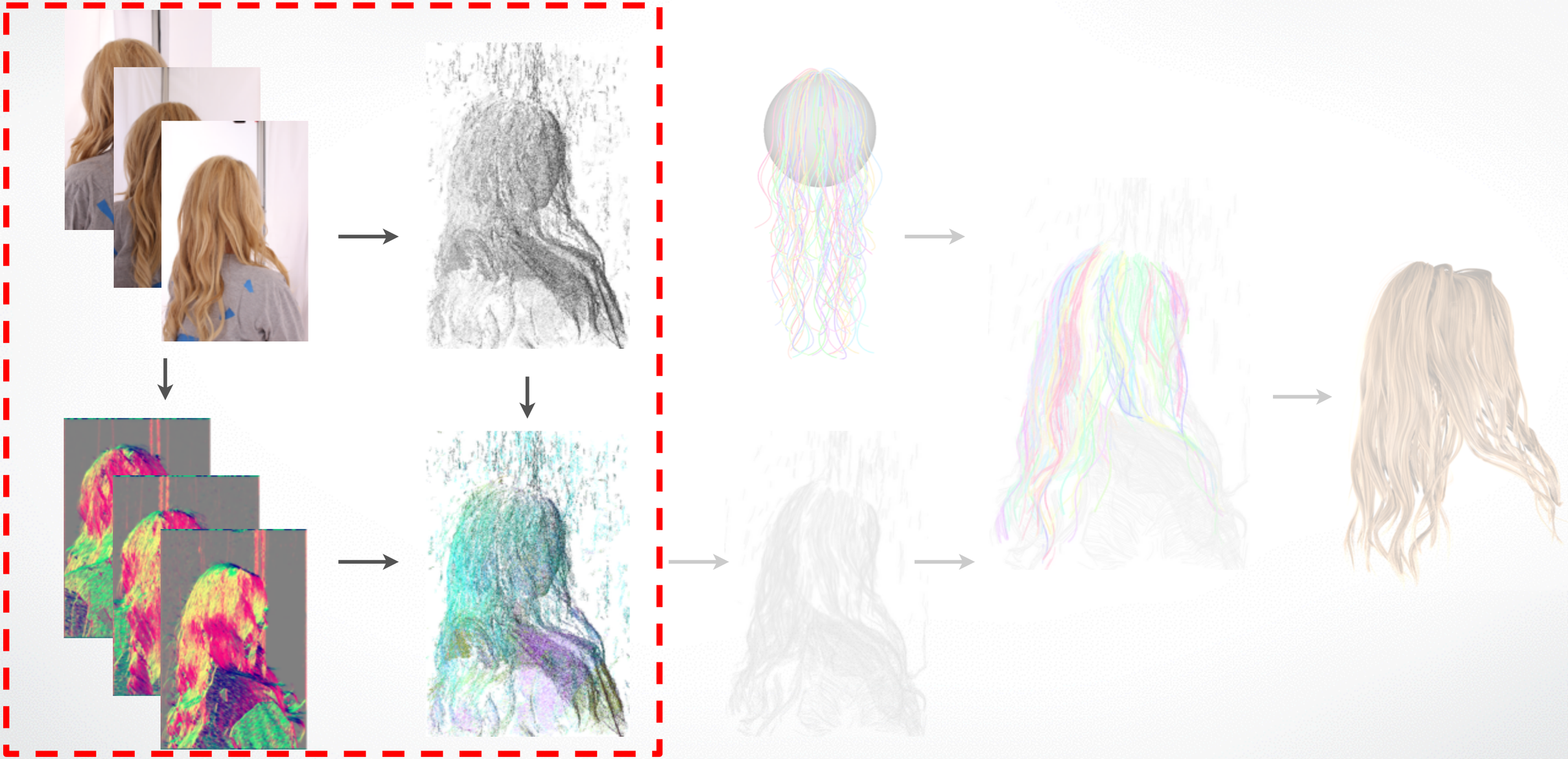

Input images
3D orientation field
Database
Cover strands
Fitting result
Final output

Capture Setup

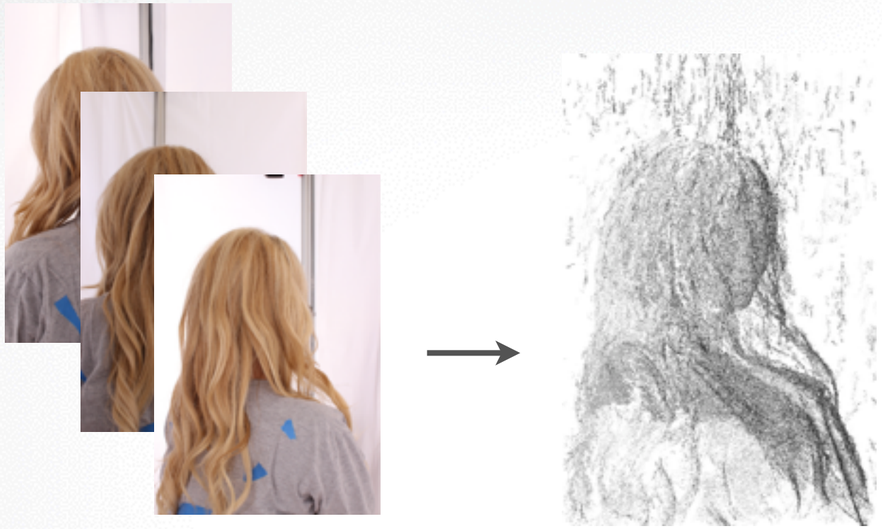
Multi-view stereo

Input images

Point Cloud Reconstruction



Point Cloud Reconstruction



PMVS [Furukawa et al. 2010]
MLS [Levin et al. 1998]

Point Cloud Reconstruction

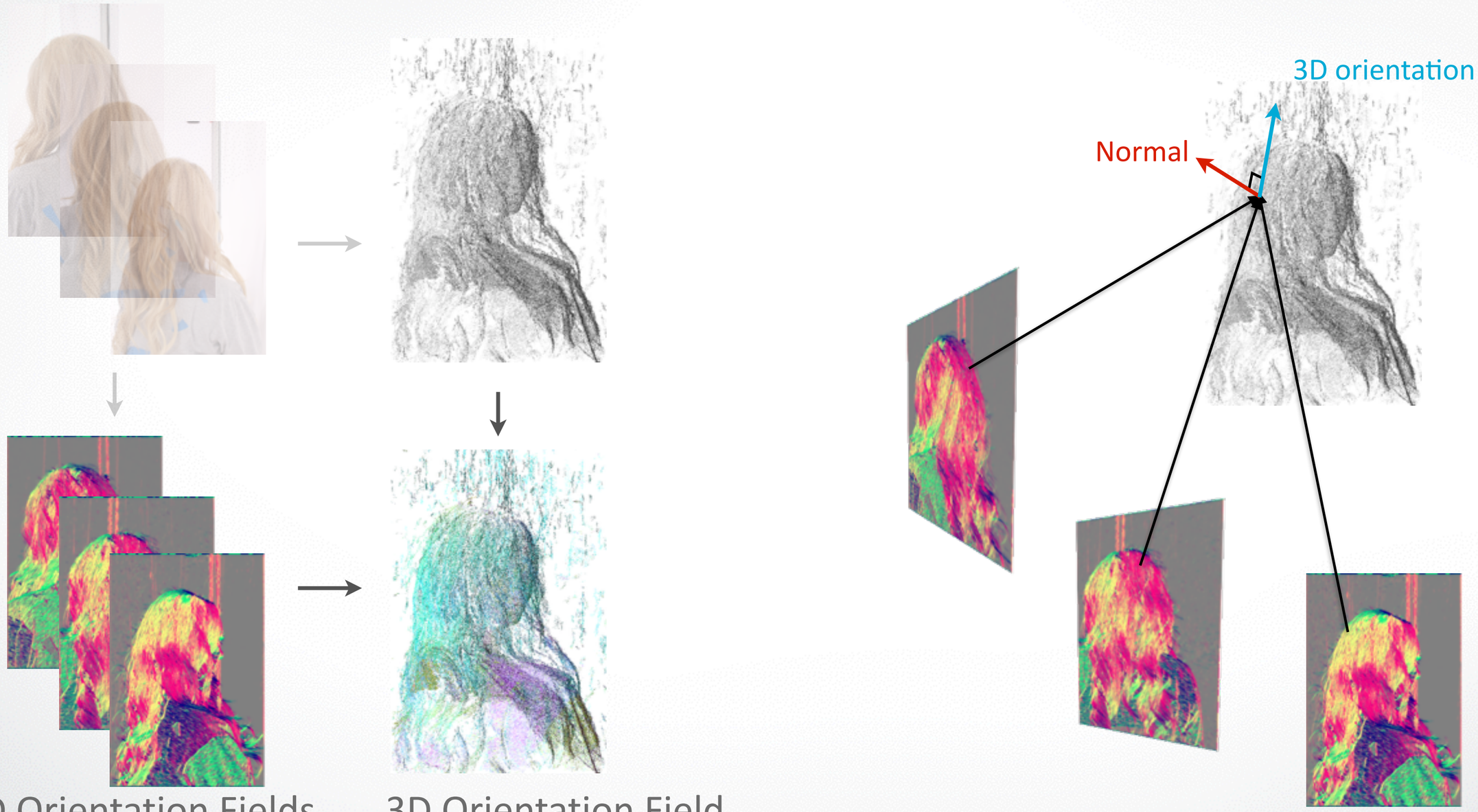
PMVS

MLS [Levin et al. 1998]

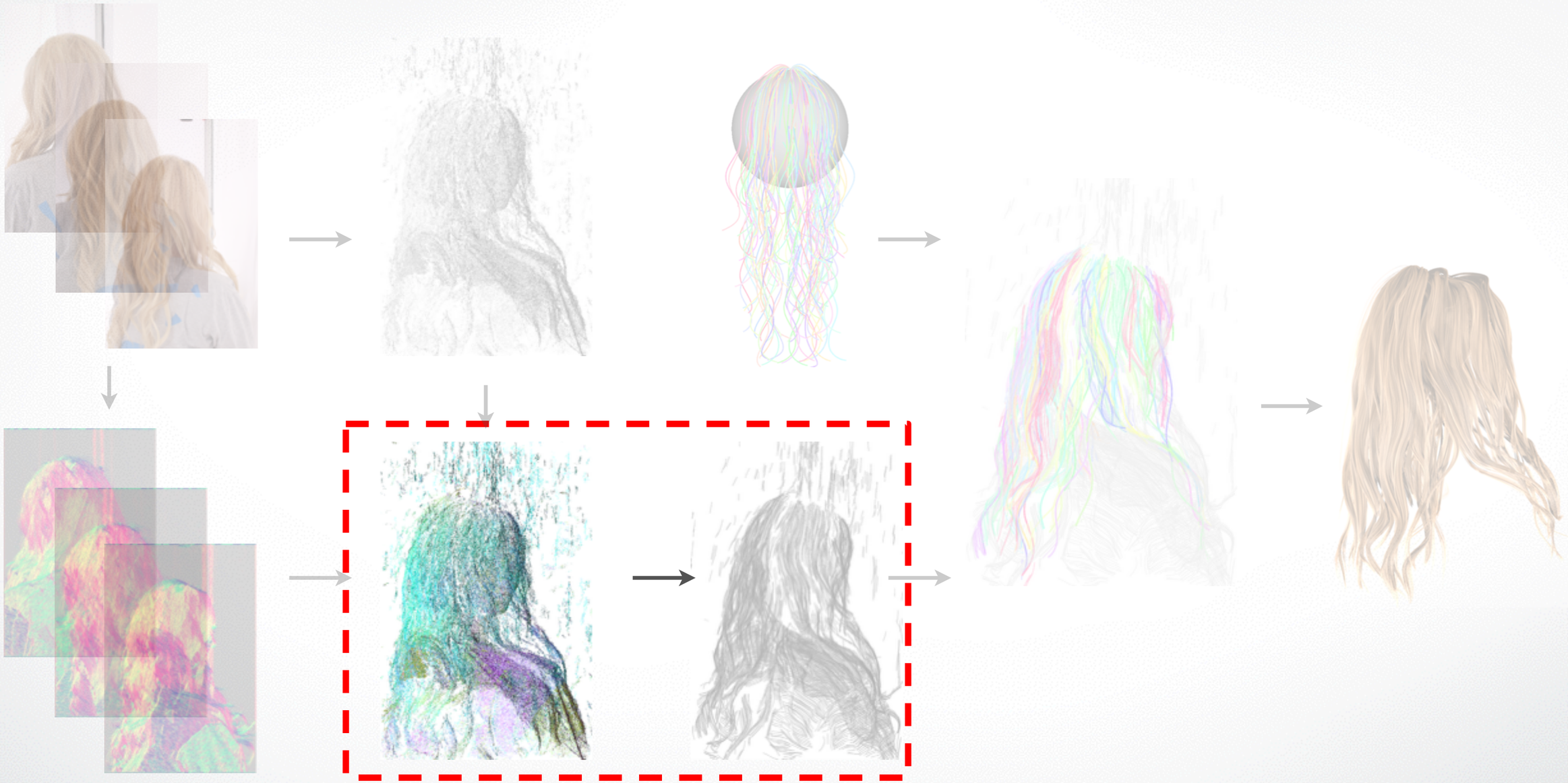
2D Orientation Fields

Detect dominant local orientation [Pair et al. 2004]

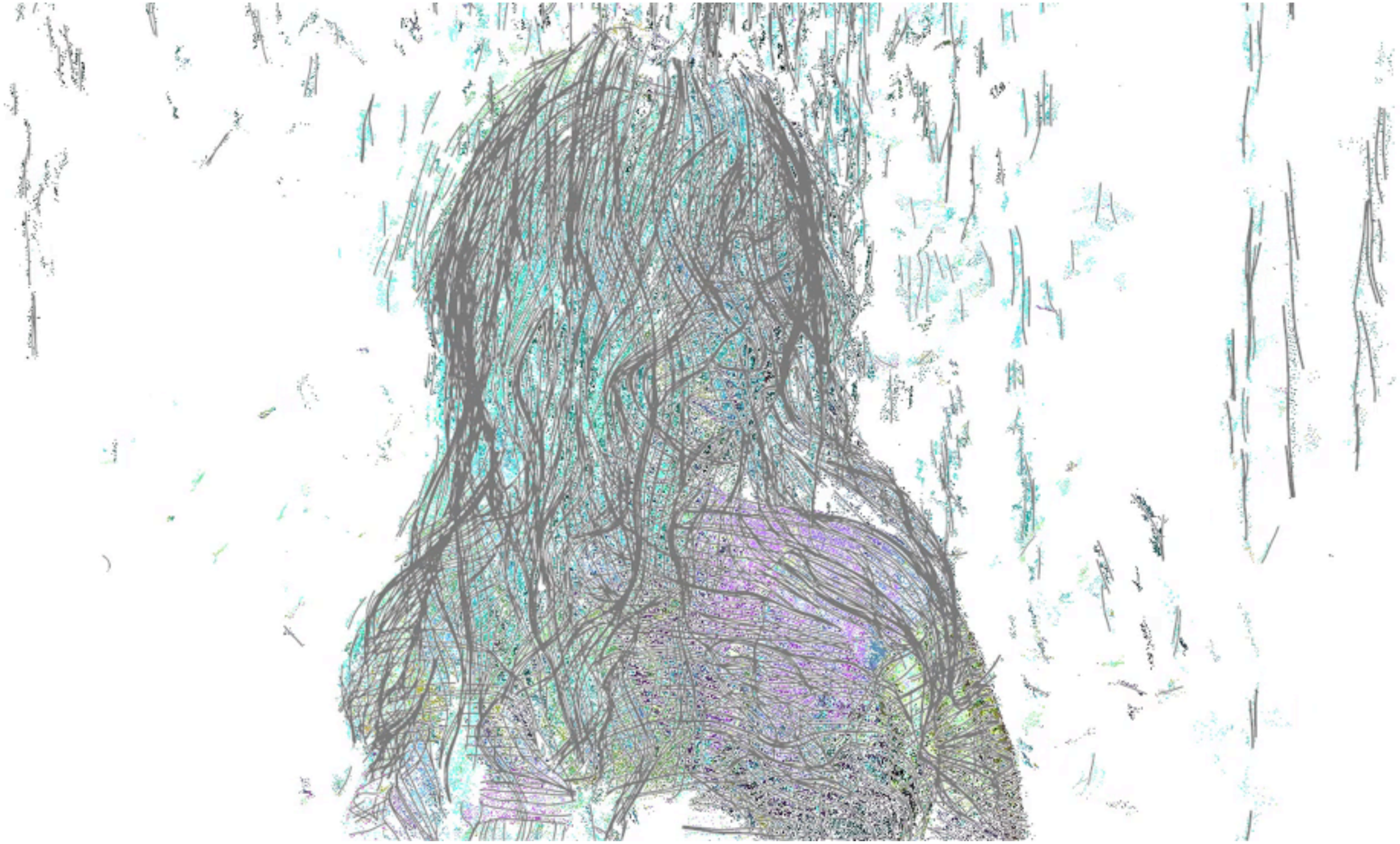
Point Cloud Reconstruction



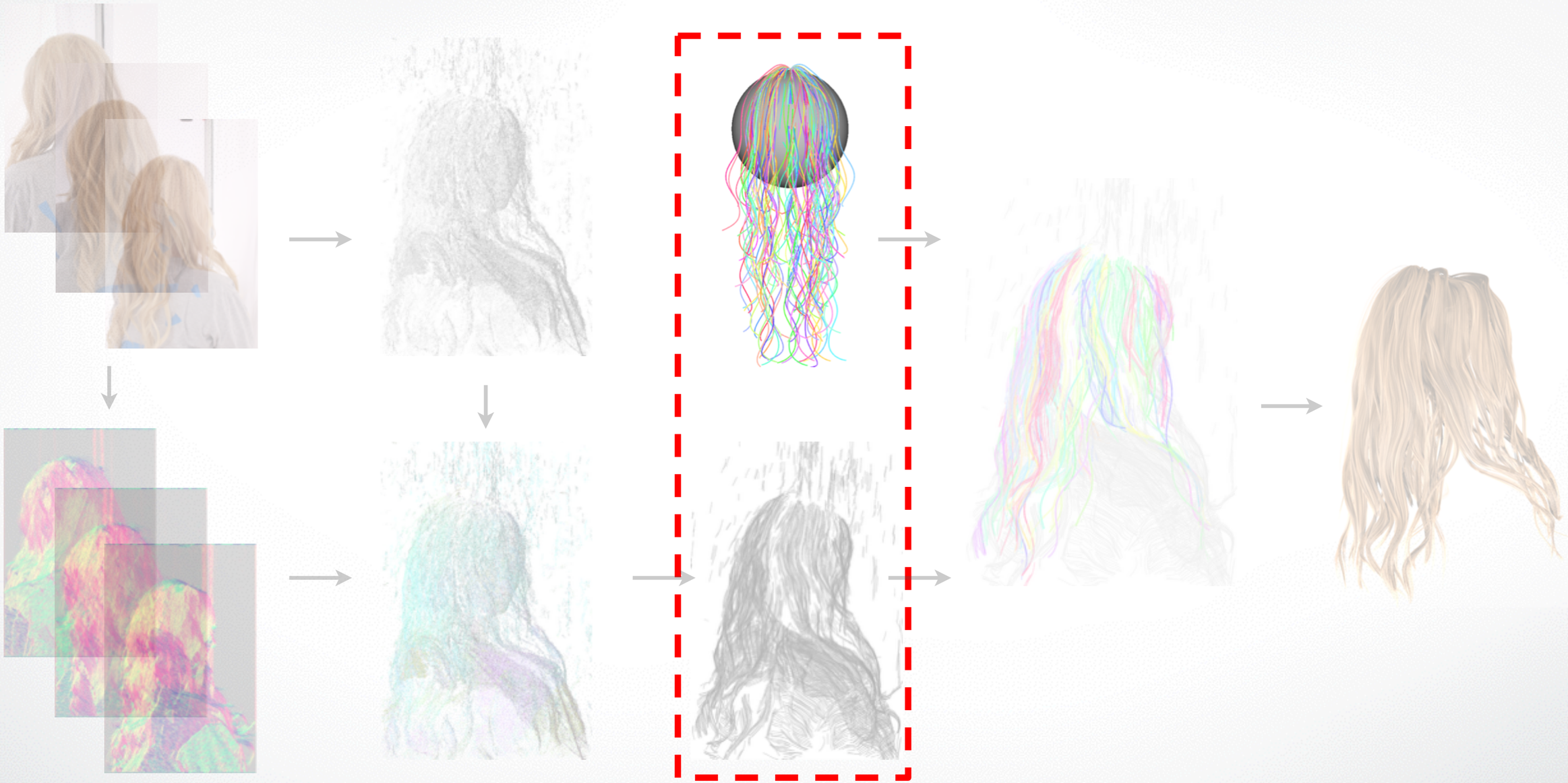
Cover Strand Generation



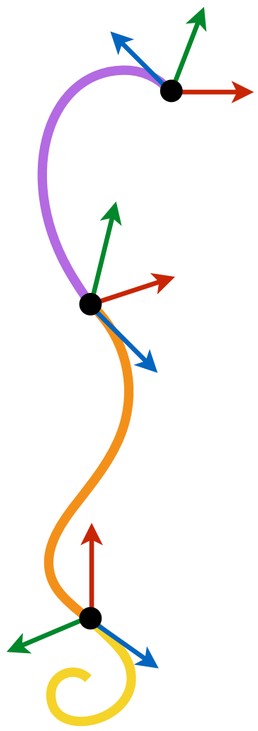
Cover Strand Generation



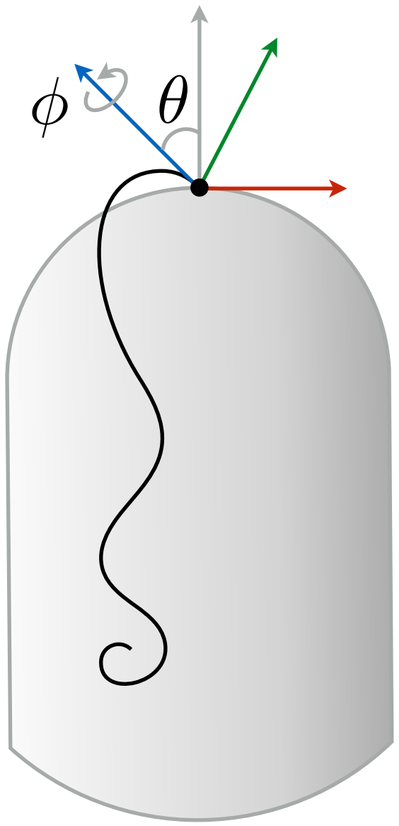
Strand Simulation



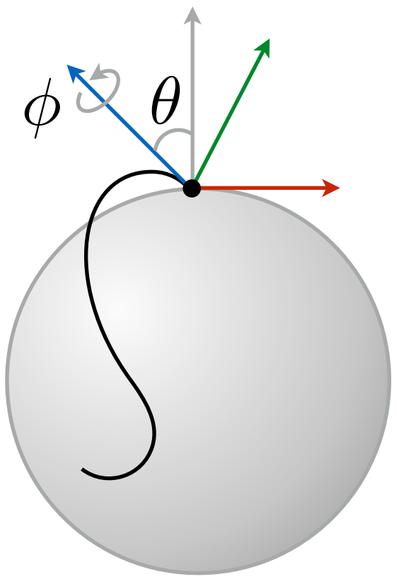
Strand Simulation



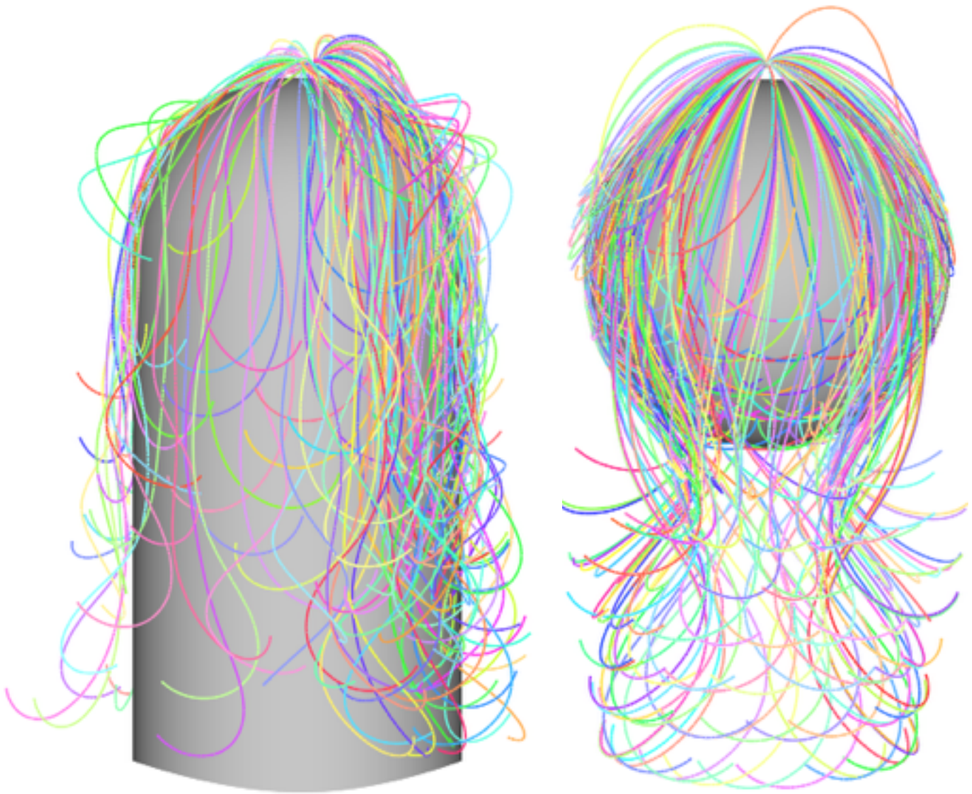
(a) Super-Helices
[Bertails et al. 2005]



(b) Cylindric
boundary



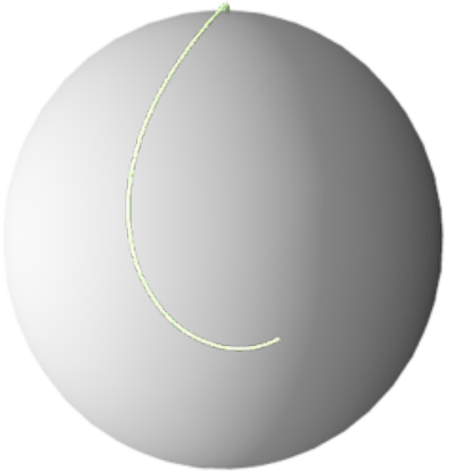
(c) Spheric
boundary



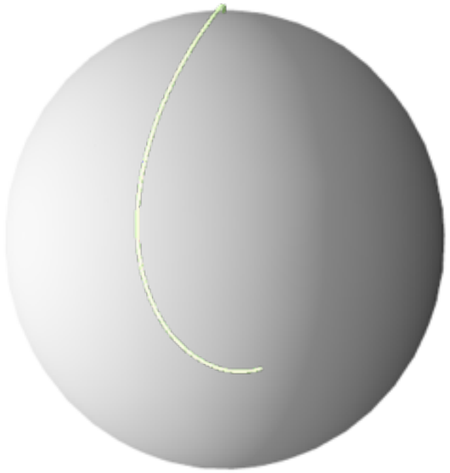
(d) Simulated databases

Strand Simulation

Different simulation parameters



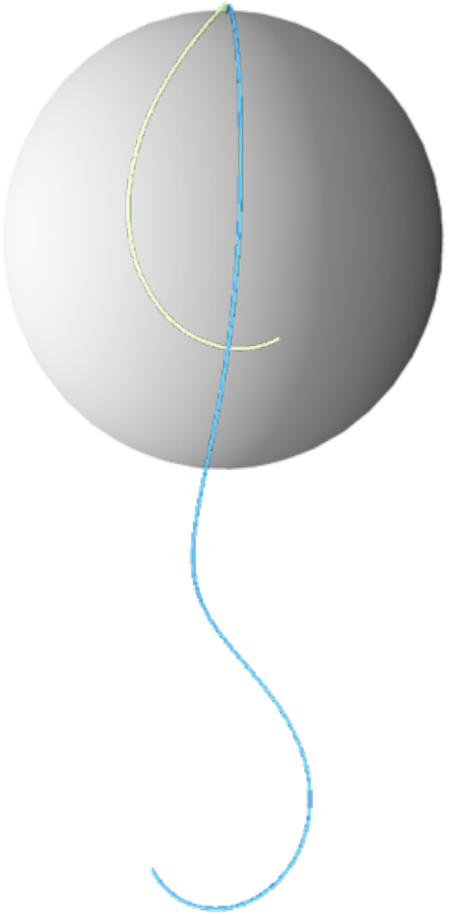
length L = 100mm
curvature k = 0.04mm^{-1}
stiffness = 2.0



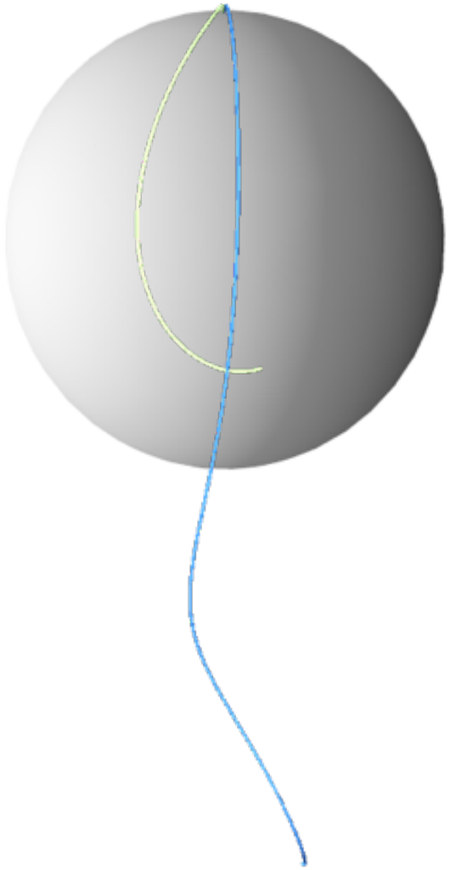
length L = 100mm
curvature k = 0.04mm^{-1}
stiffness = 1.5

Strand Simulation

Different simulation parameters



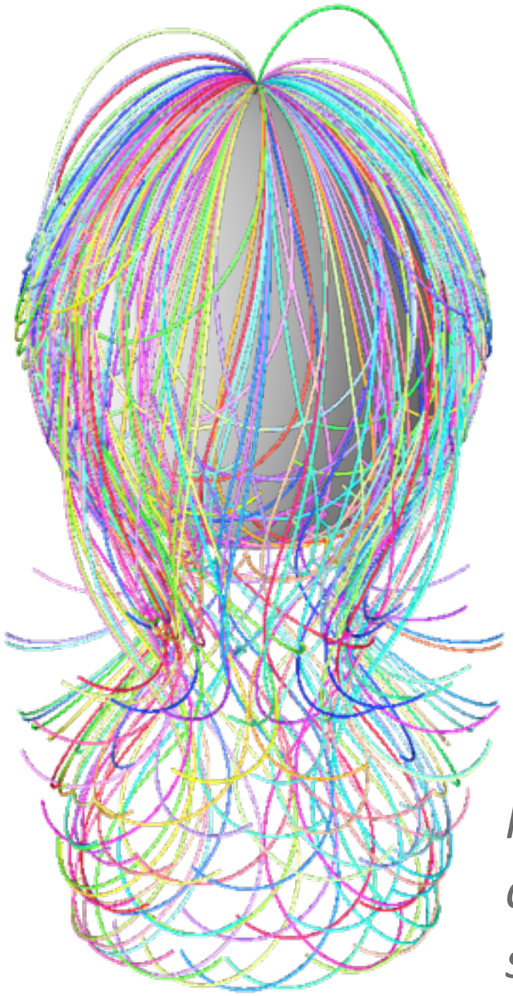
length L = 400mm
curvature k = 0.04mm^{-1}
stiffness = 2.0



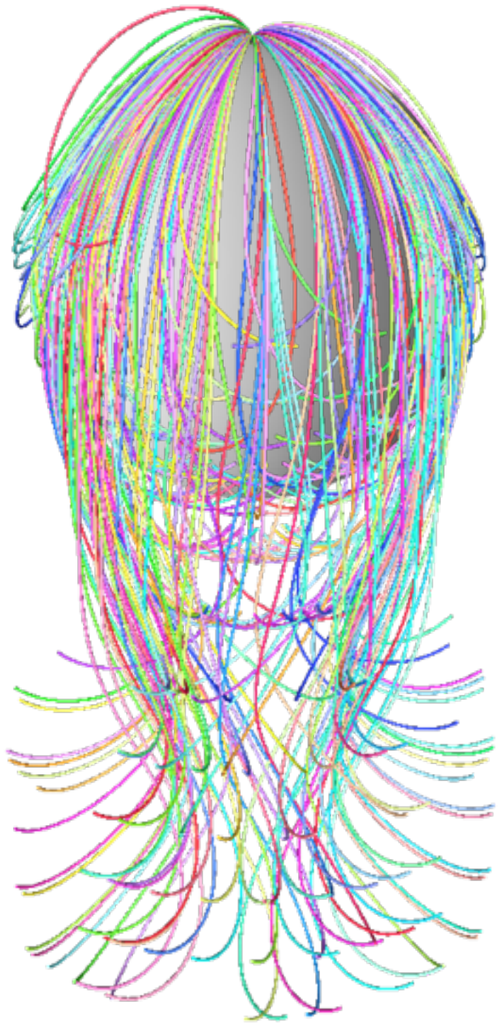
length L = 400mm
curvature k = 0.04mm^{-1}
stiffness = 1.5

Strand Simulation

Different simulation parameters

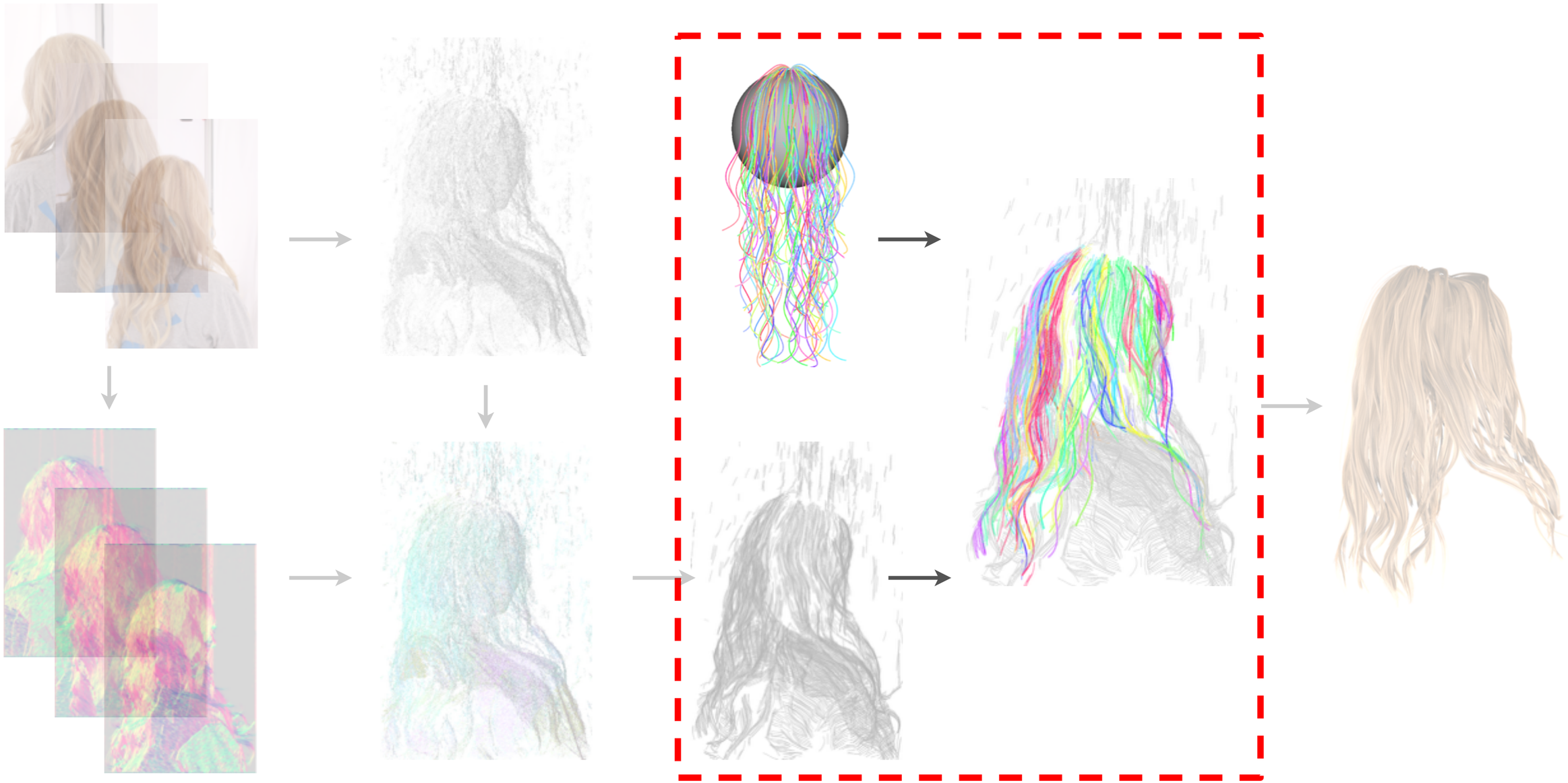


length L = 100~400mm
curvature k = 0.04mm^{-1}
stiffness = 2.0



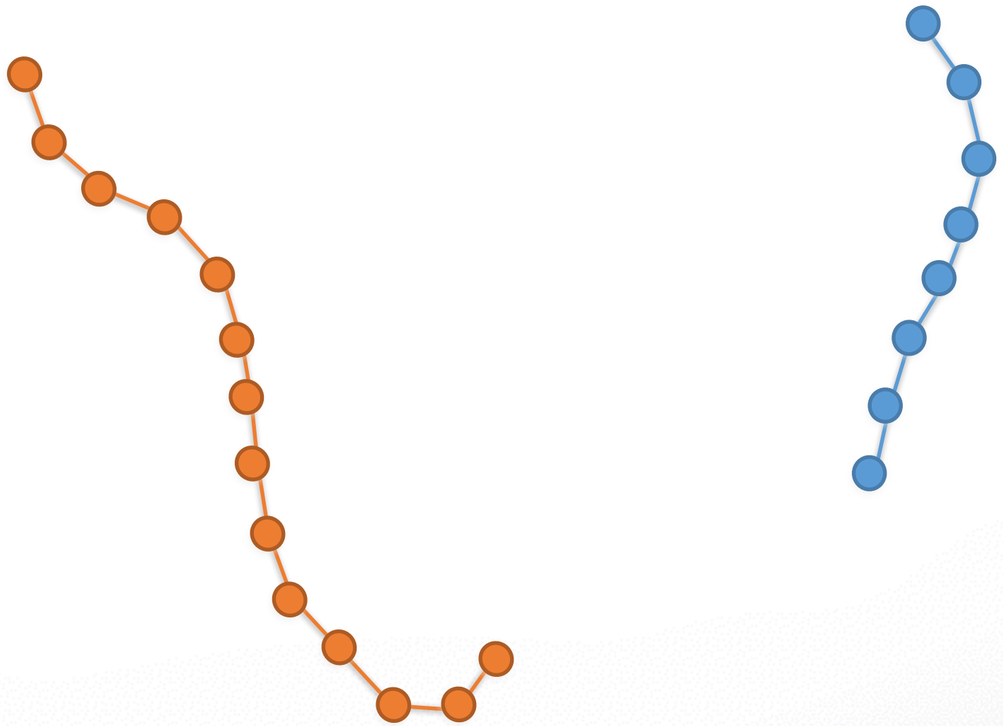
length L = 100~400mm
curvature k = 0.04mm^{-1}
stiffness = 1.5

Strand Fitting



Strand Fitting

Iterative Closest Point method [Besl and McKay 1992]



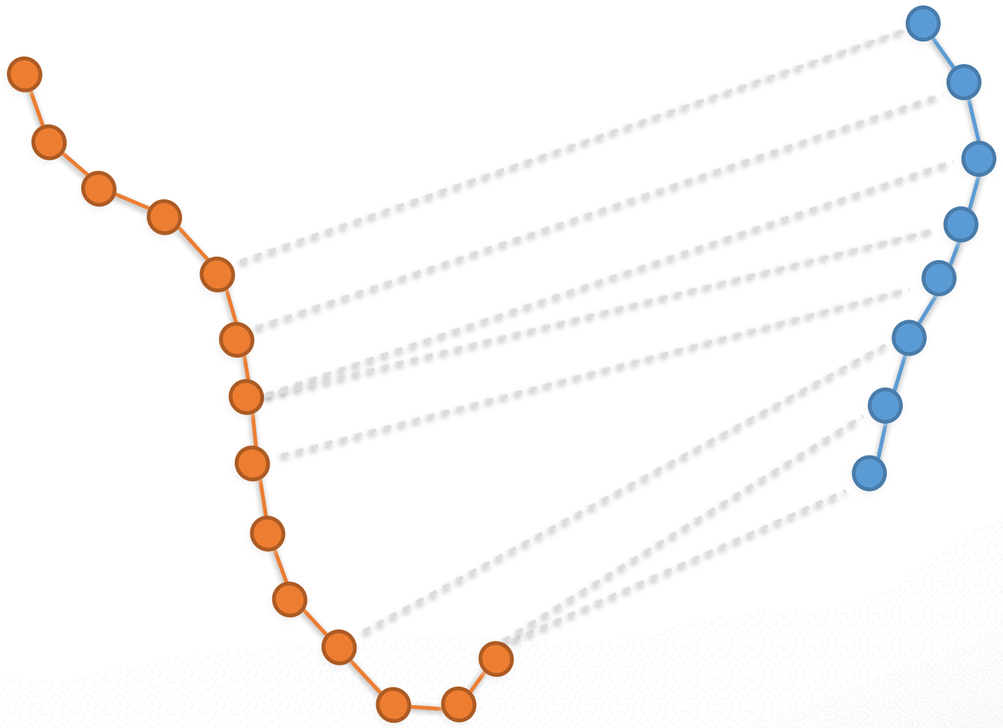
Example strand

Cover strands

Strand Fitting

Iterative Closest Point method [Besl and McKay 1992]

Correspondence



Example strand

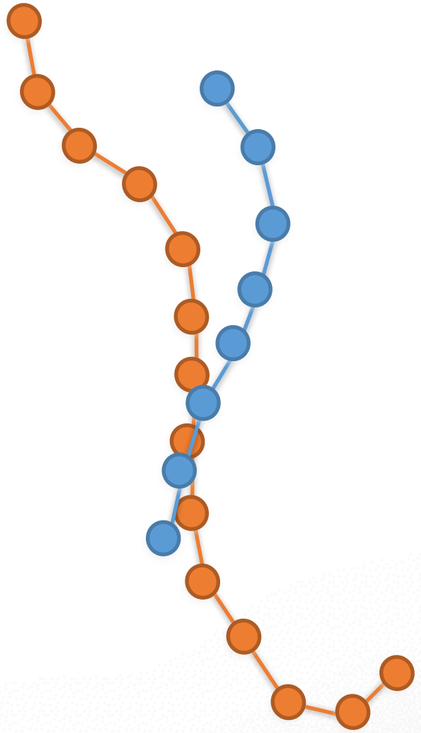
Cover strands

Strand Fitting

Iterative Closest Point method [Besl and McKay 1992]

Correspondence

Rigid transformation



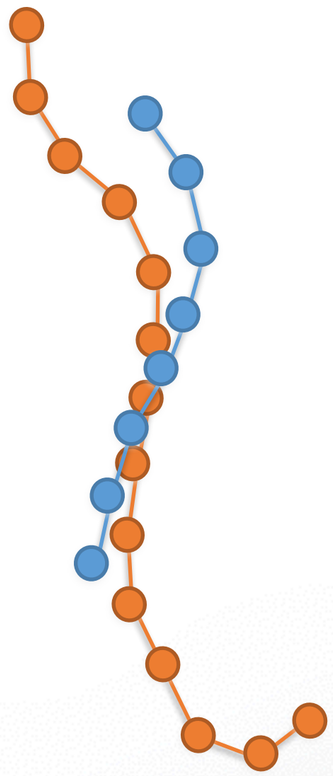
Strand Fitting

Iterative Closest Point method [Besl and McKay 1992]

Correspondence

↓

Rigid transformation



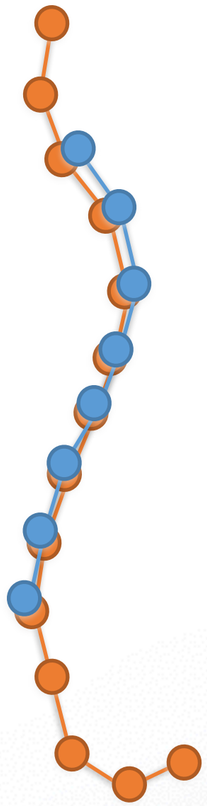
Strand Fitting

Iterative Closest Point method [Besl and McKay 1992]

Correspondence

↓

Rigid transformation



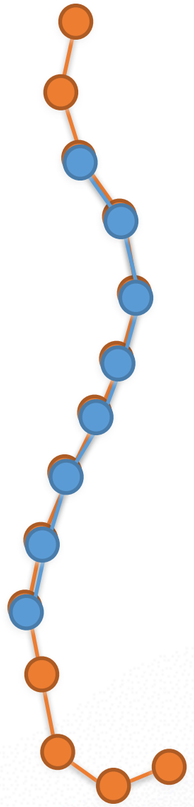
Strand Fitting

Iterative Closest Point method [Besl and McKay 1992]

Correspondence

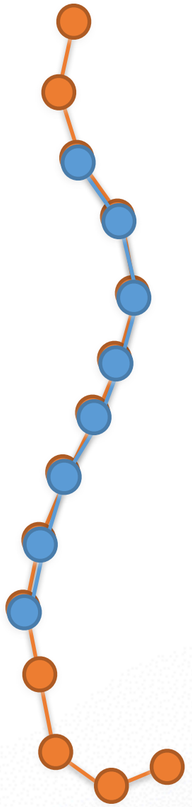
↓

Rigid transformation



Strand Fitting

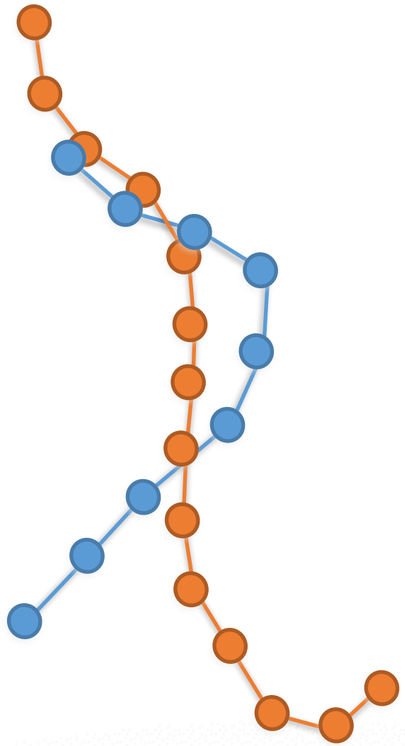
Fitting error < threshold



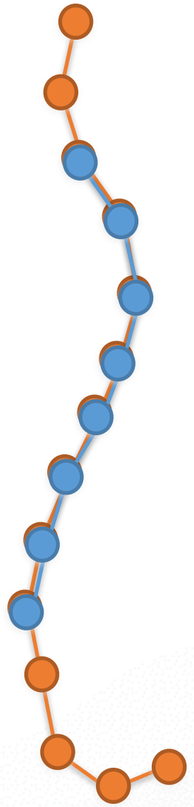
Valid vote

Strand Fitting

Fitting error >= threshold



Invalid vote



Valid vote

Strand Fitting

Example strands

Cover strands

Strand Fitting

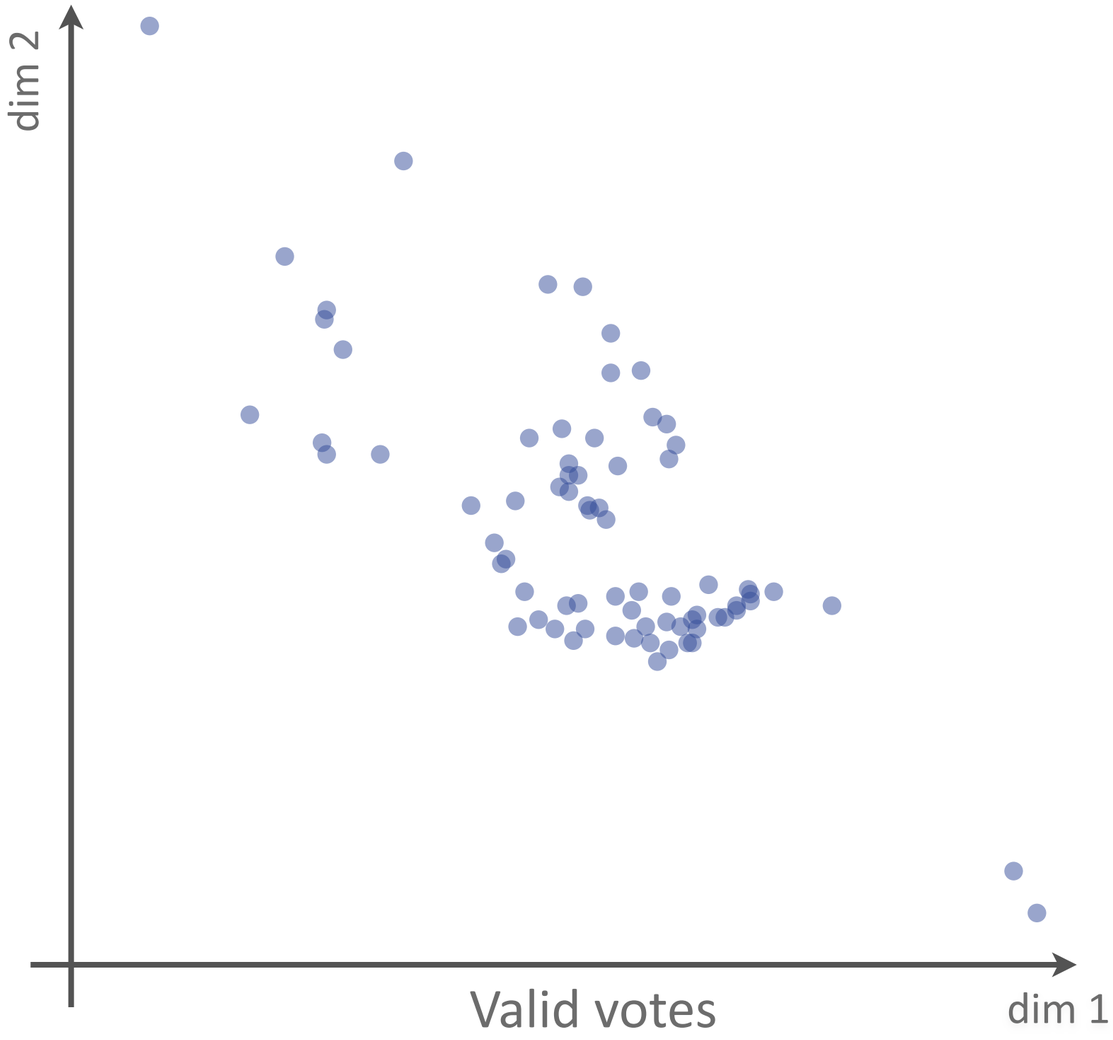
Example strand

Cover strands

Strand Fitting

Example strand

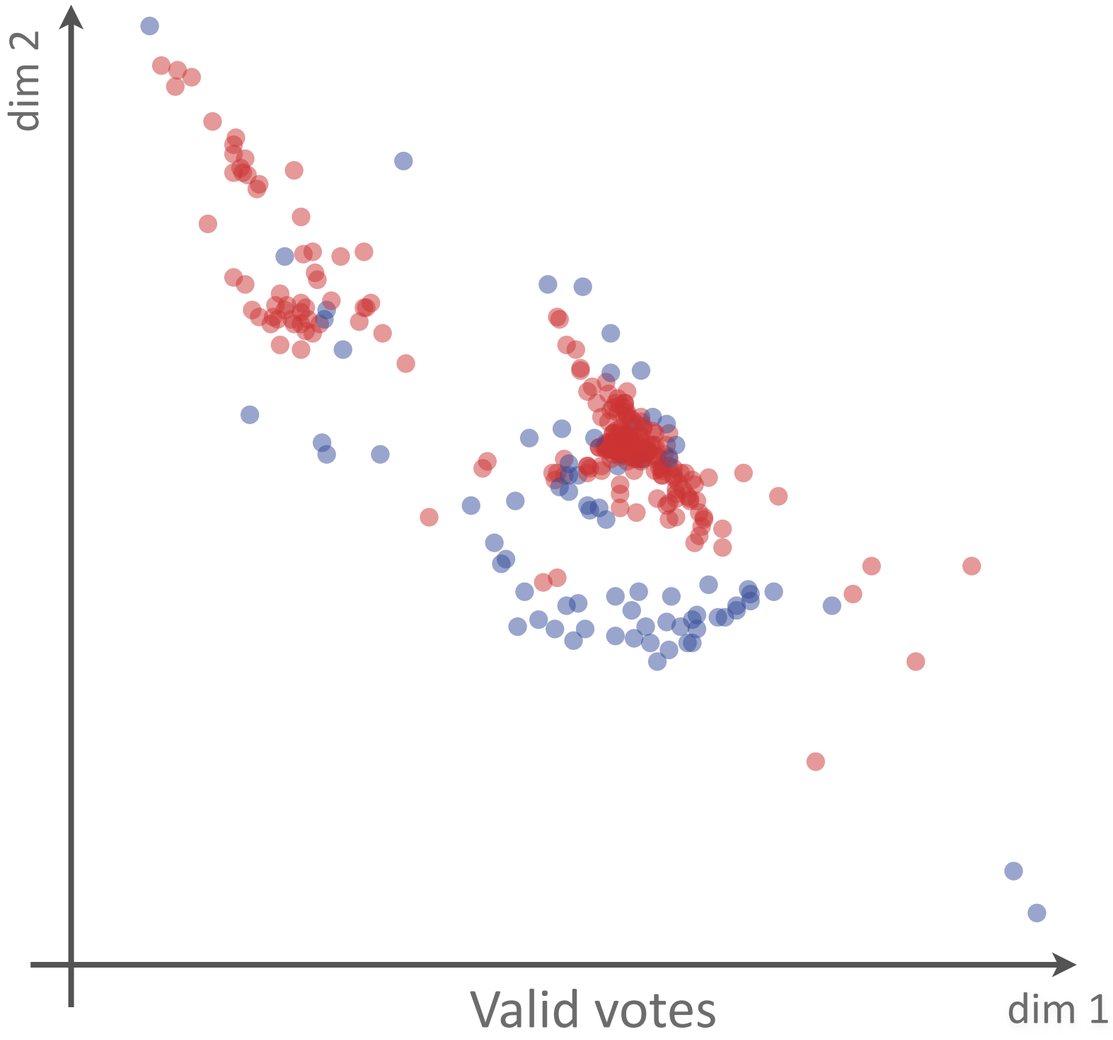
Cover strands



Strand Fitting

Example strand

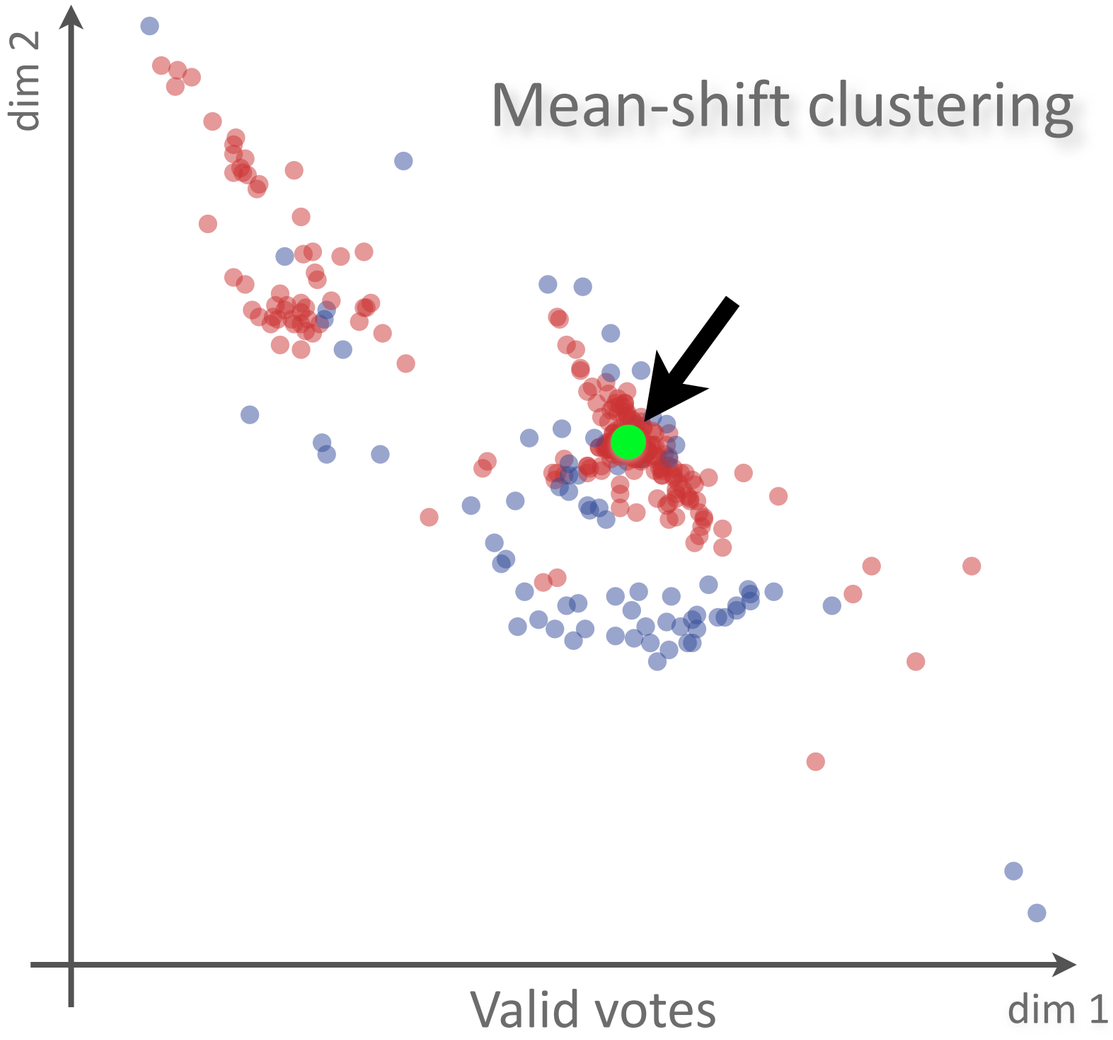
Cover strands



Strand Fitting

Example strand

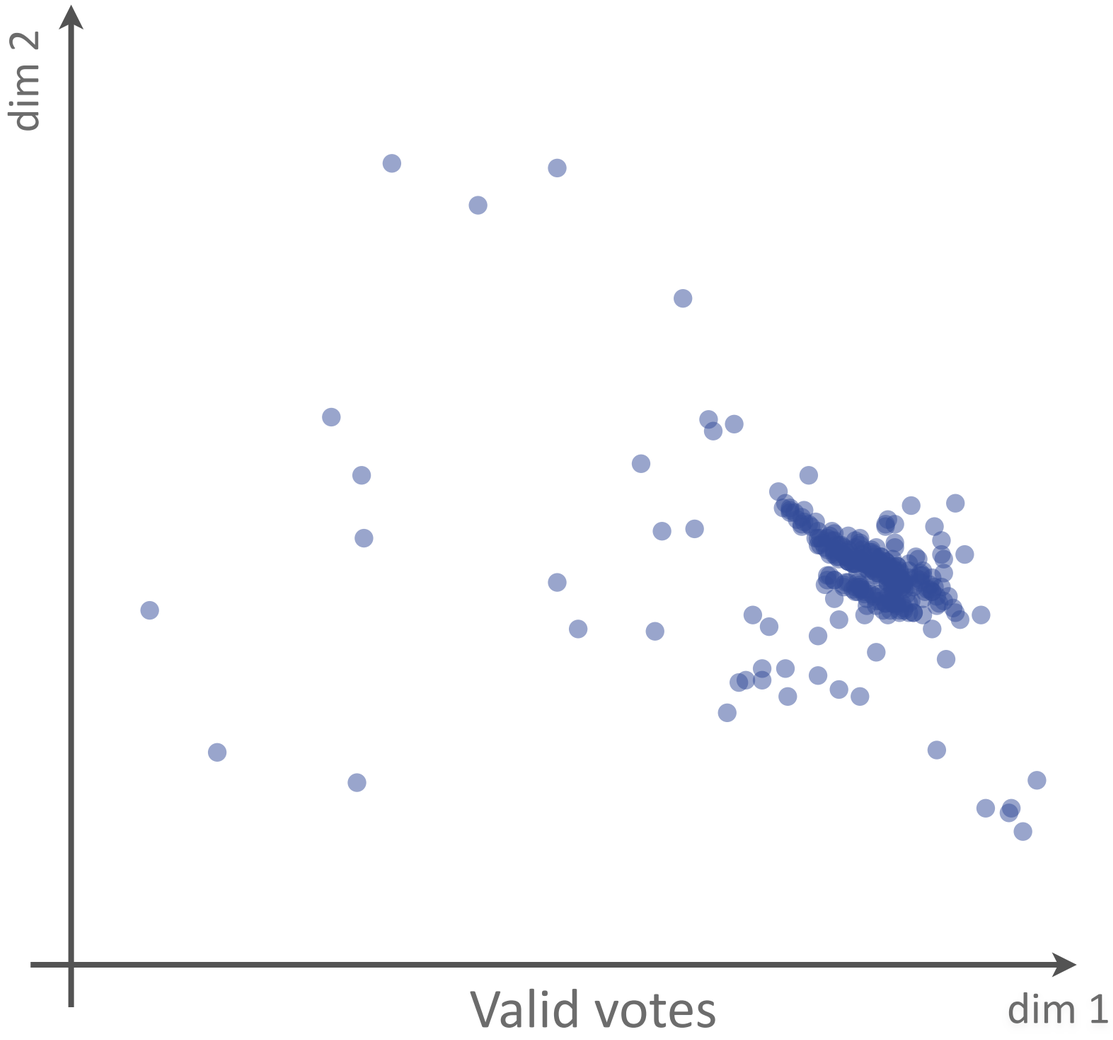
Cover strands



Strand Fitting

Example strand

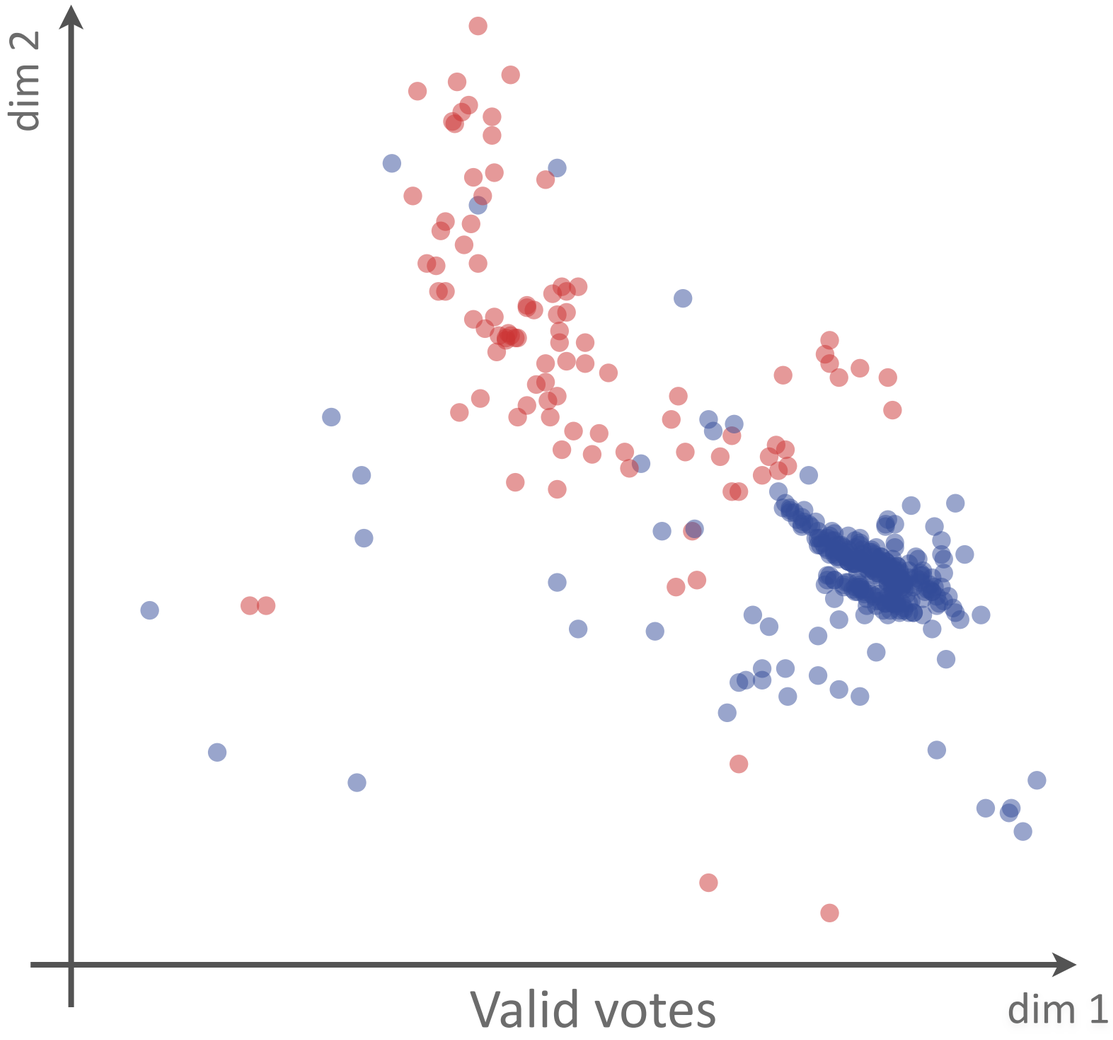
Cover strands



Strand Fitting

Example strand

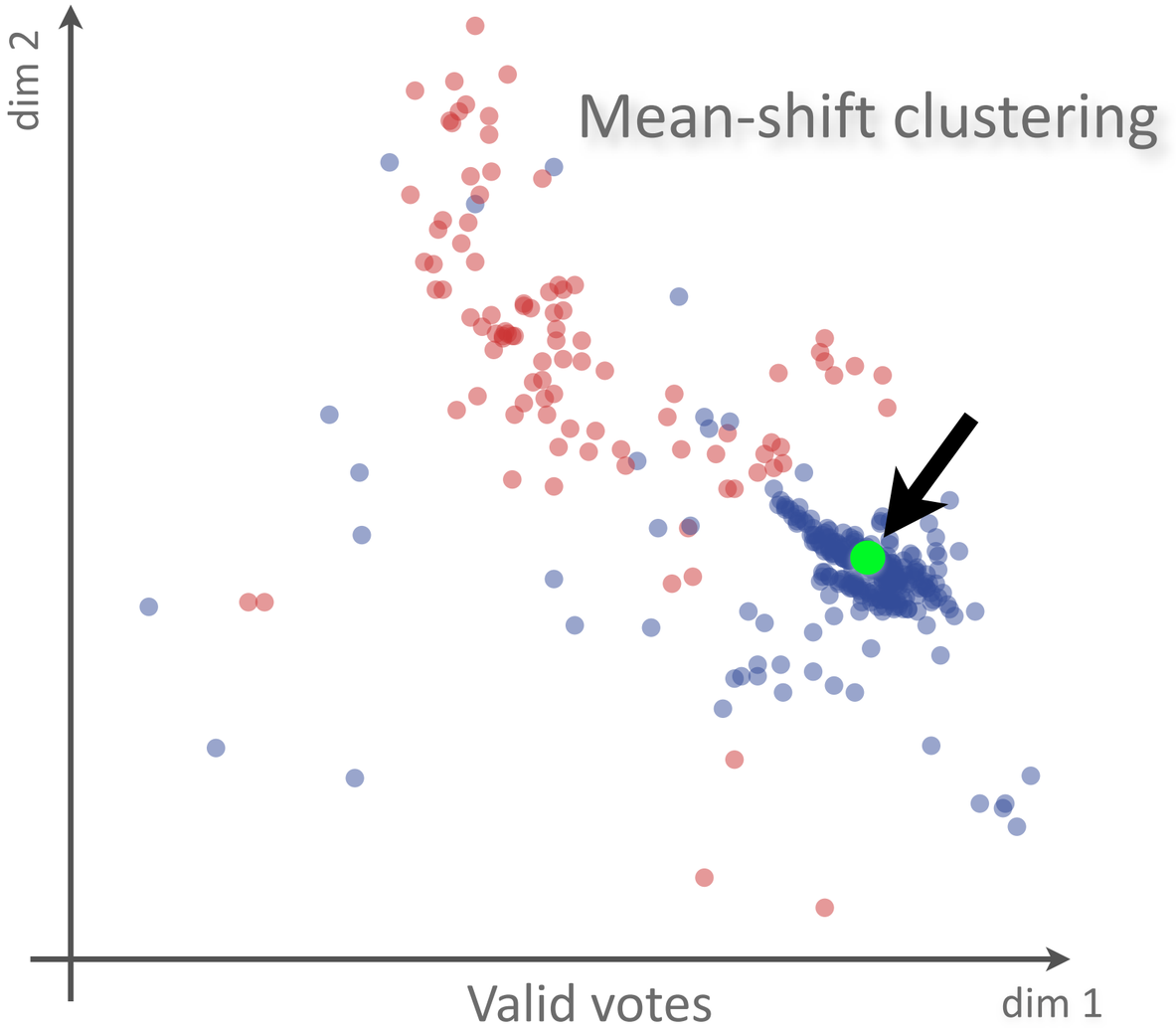
Cover strands



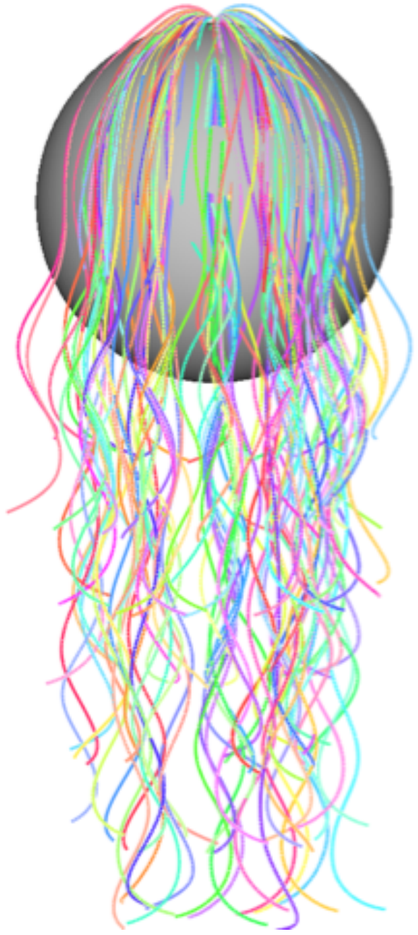
Strand Fitting

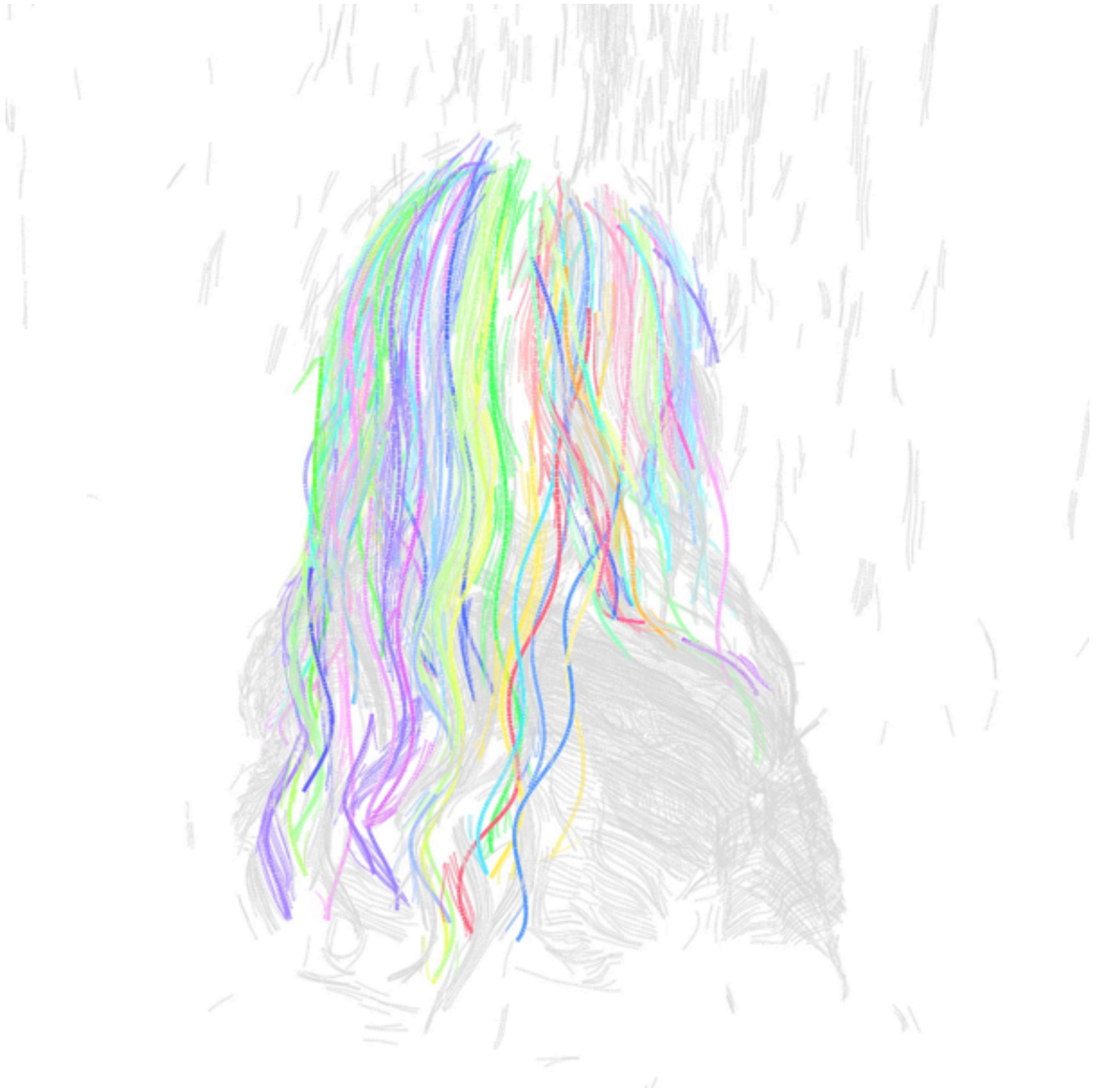
Example strand

Cover strands

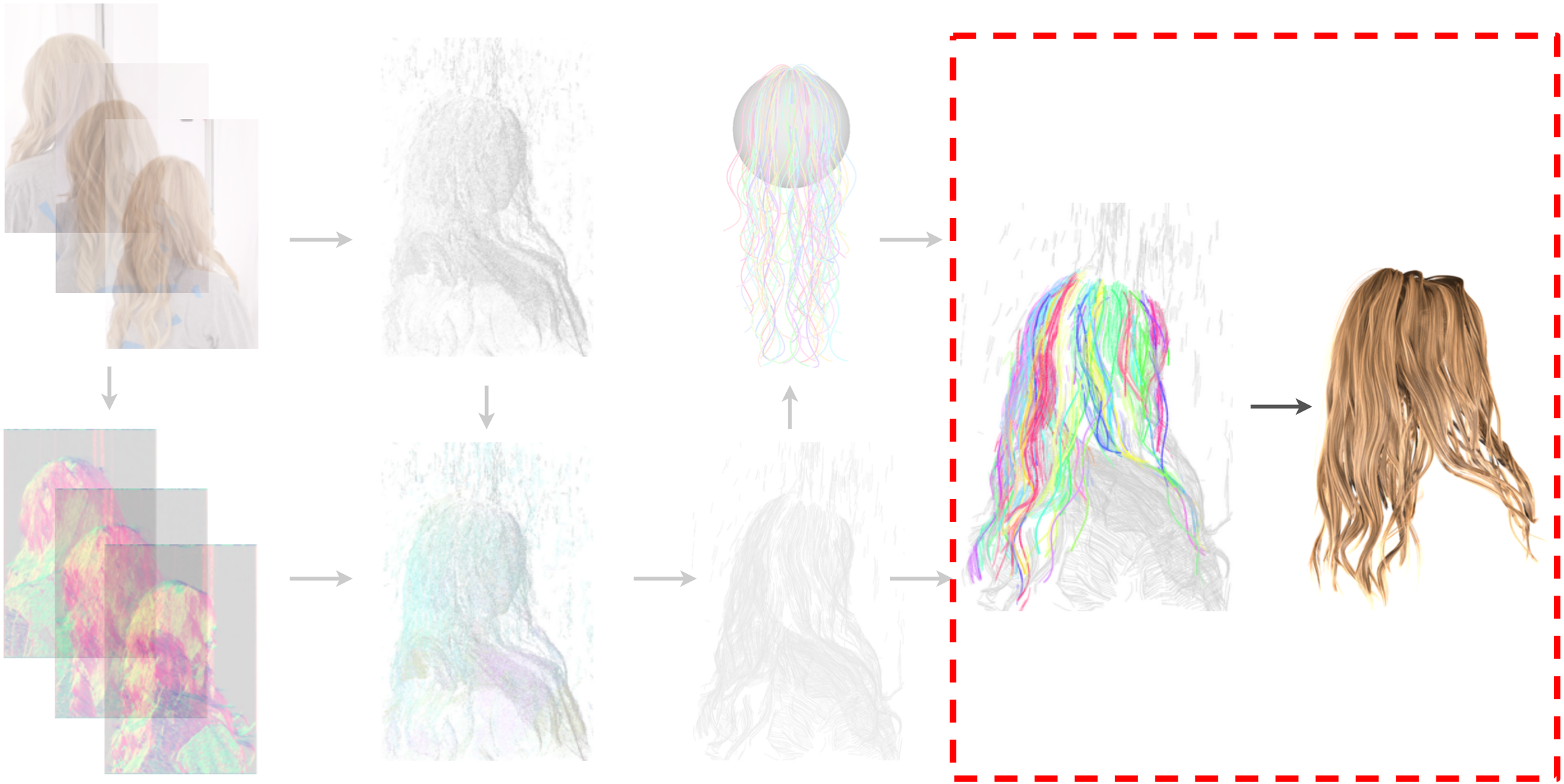


Strand Fitting

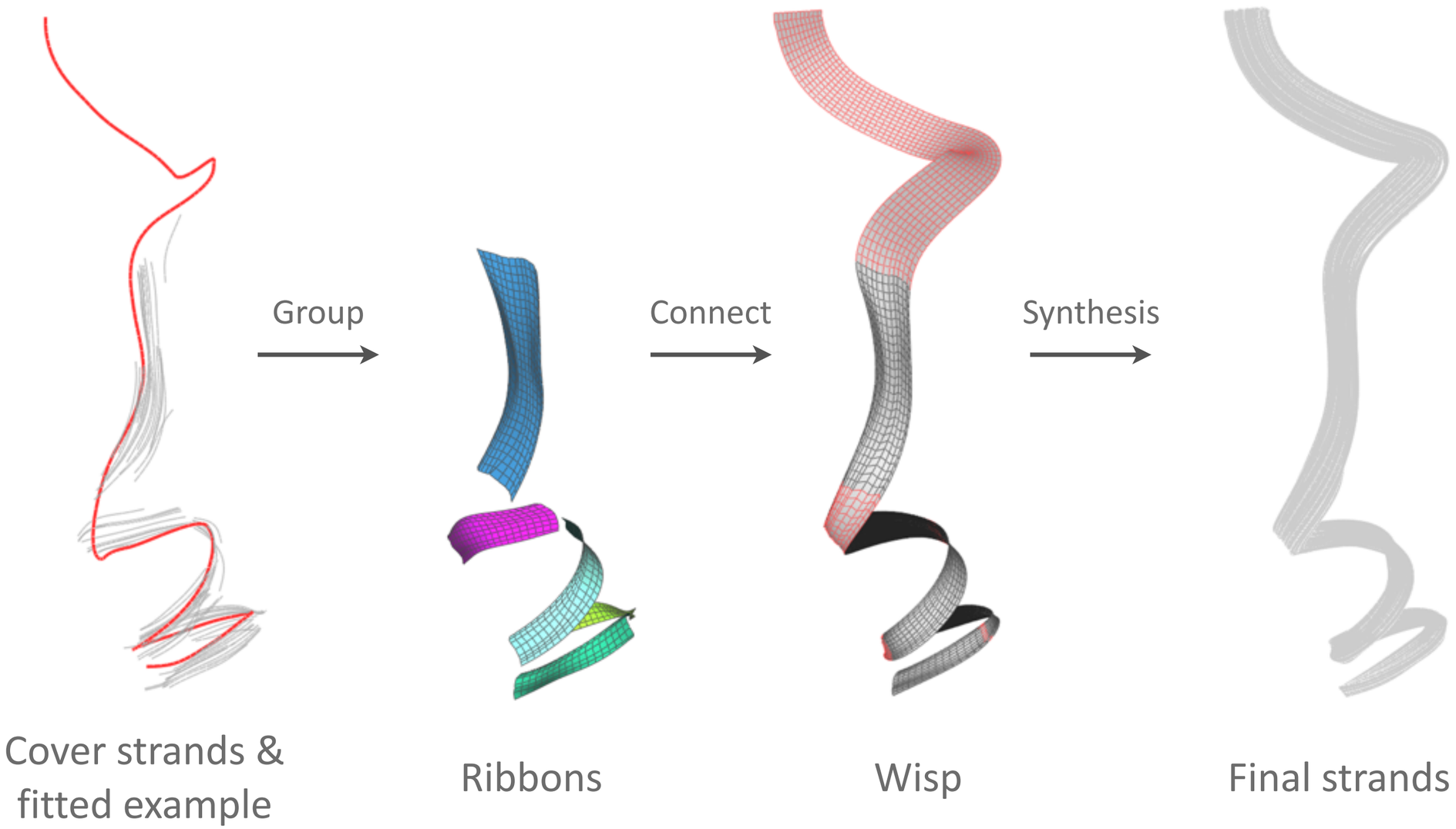




Strand Synthesis



Strand Synthesis



Comparison

Reference photo

Our result

[Luo et al. 2013]

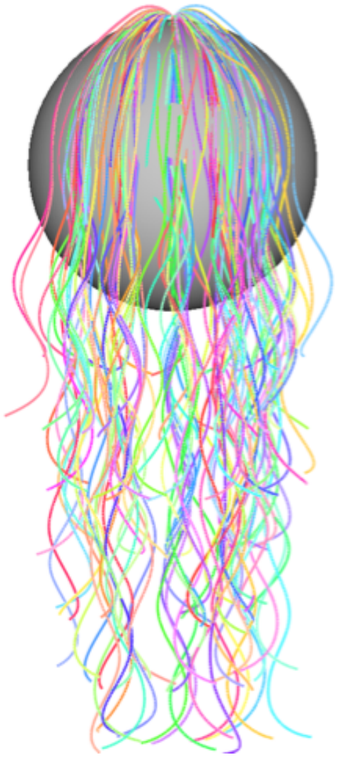
Comparison

Reference photo

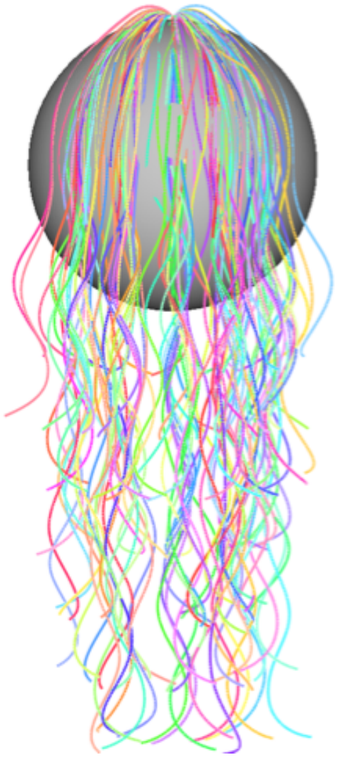
Our result

[Luo et al. 2013]

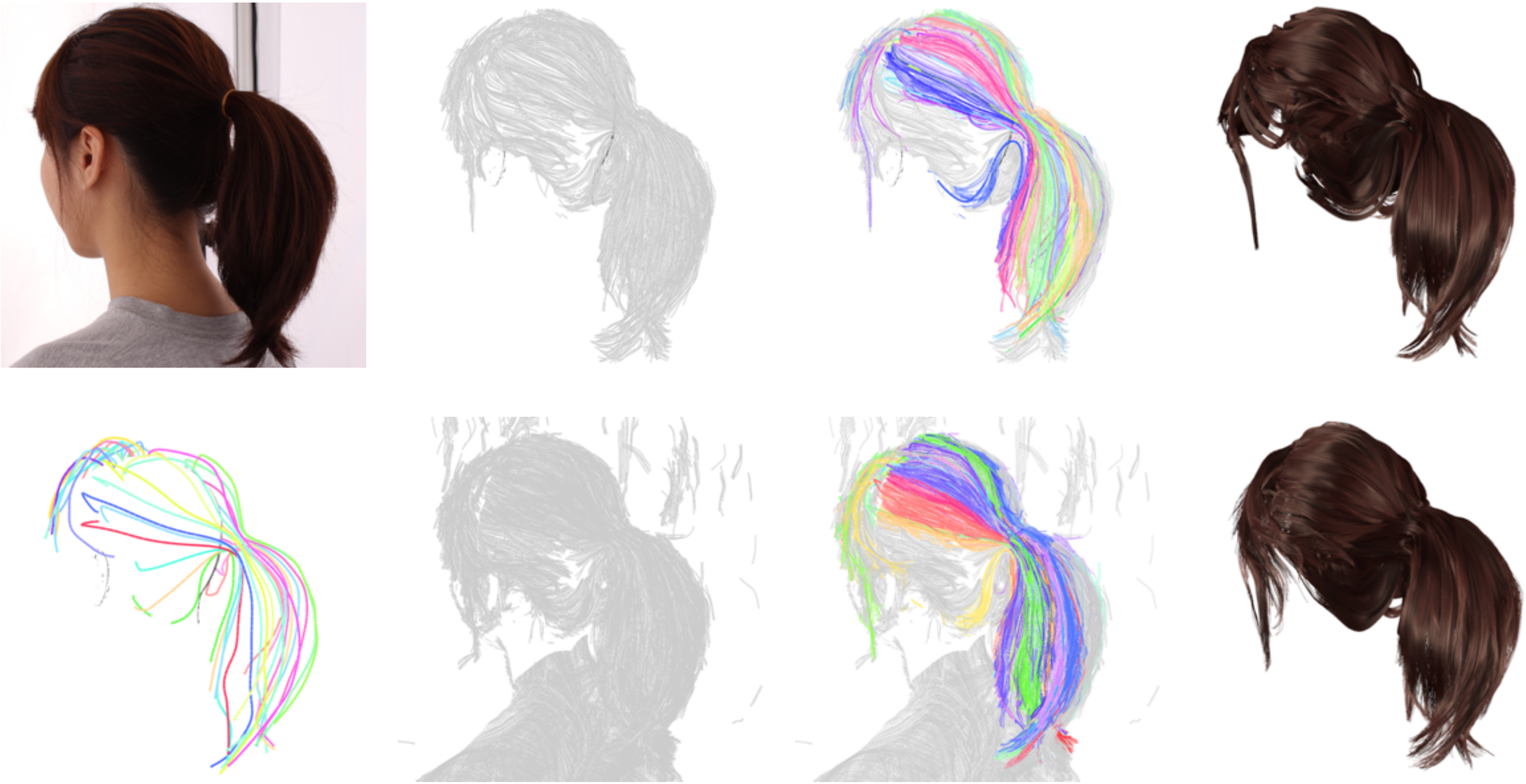
Result: Kirsty Dataset



Result: Kirsty Dataset

Result: Ponytail



Result: Lee1 Dataset

Reference photo

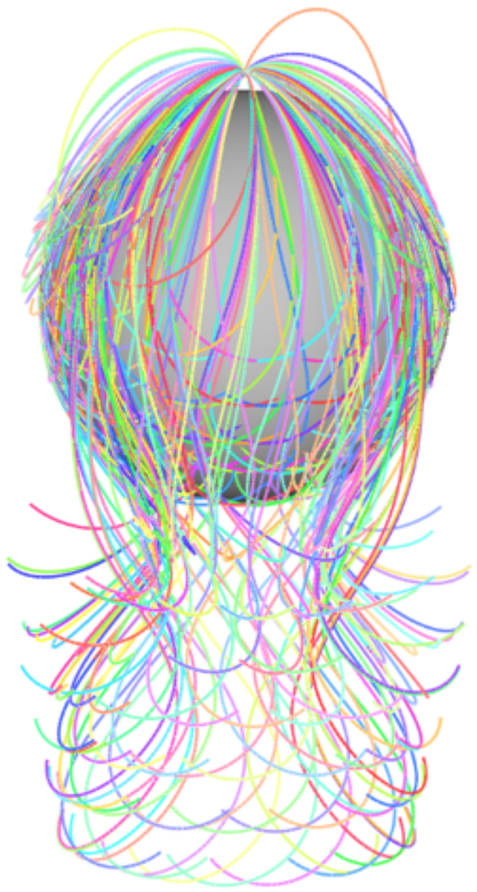
Our result

Simulated example

Result: Lee2 Dataset

Reference photo

Our result



Simulated example

Result: Alice Dataset

Reference photo

Our result

Simulated example

Evaluation

Different numbers of example strands

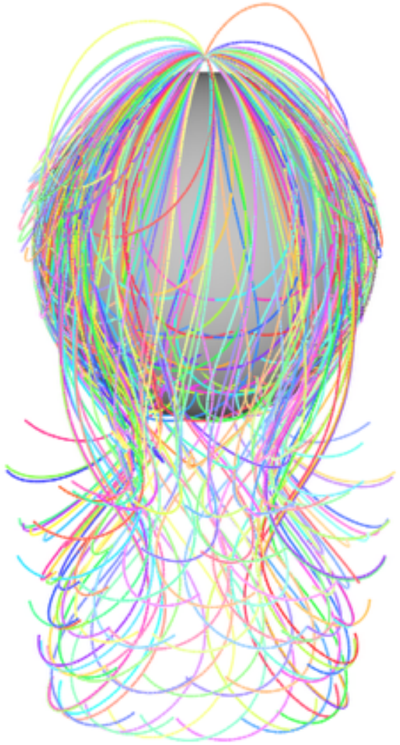
n = 256

n = 128

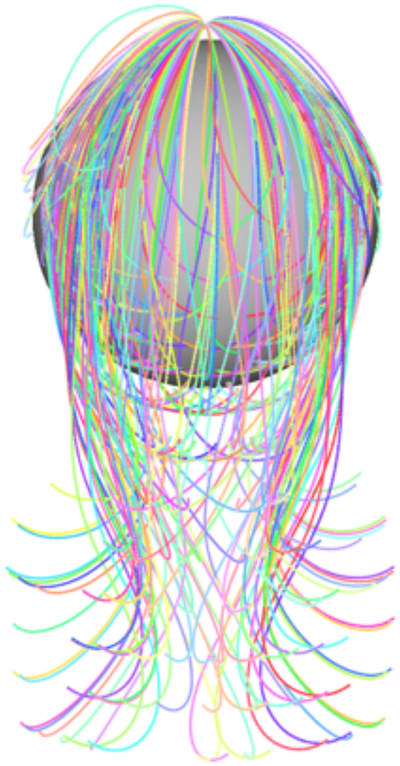
n = 64

Evaluation

Different simulation parameters



stiffness = 2.0



stiffness = 1.5

Contributions

A general data-driven framework for 3D hair capture

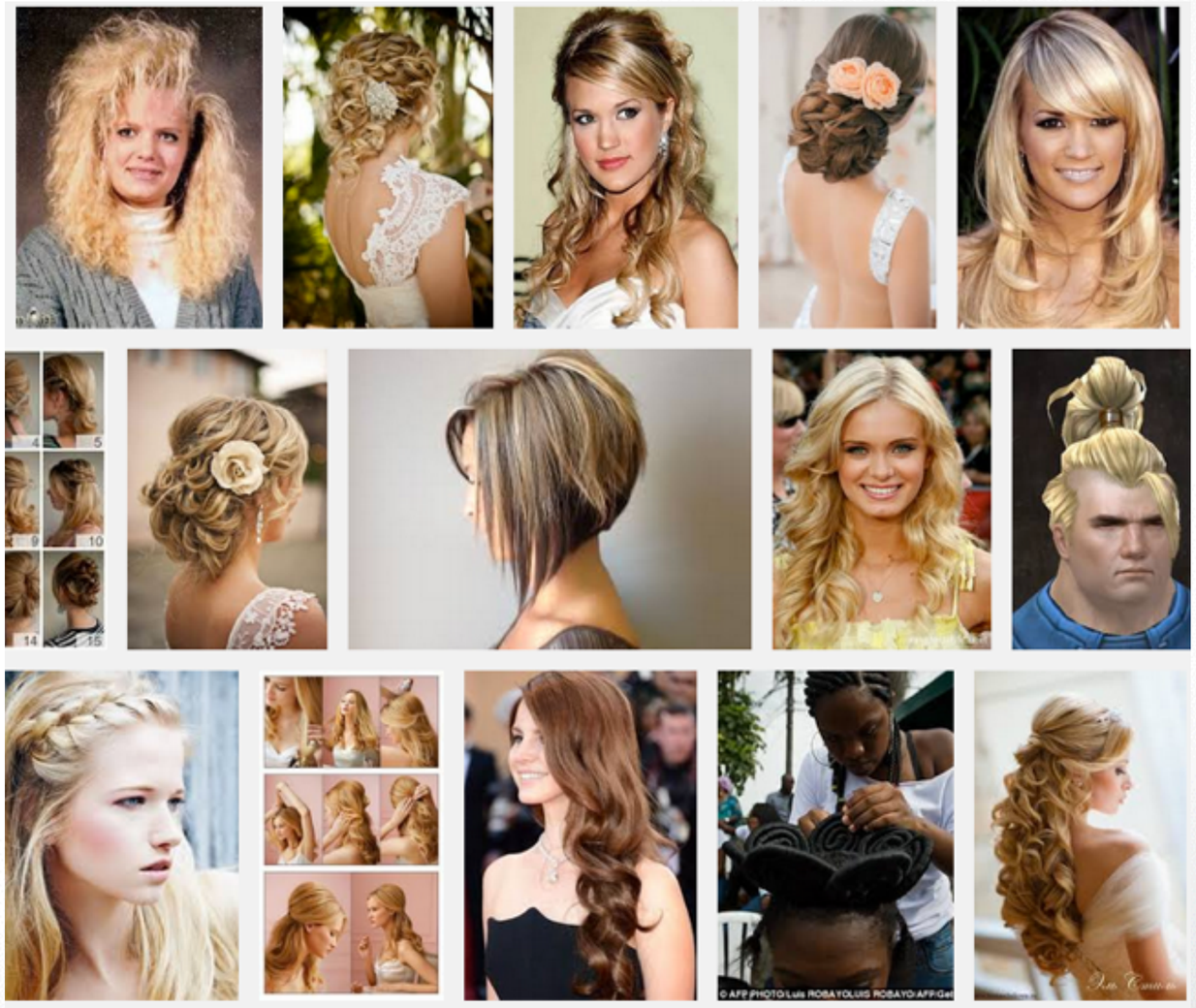
An efficient method to simulate databases of example strands

A robust fitting algorithm to discover structurally plausible hair configurations

Future work

General-purpose database

Learning and classification



Future work

General-purpose database

Learning and classification

More challenging constrained hairstyles

Procedural priors

Future work

General-purpose database

Learning and classification

More challenging constrained hairstyles

Procedural priors

Cost-effective capture setup

Consumer-level depth camera

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