Advanced Data Visualization

CS 6965

Spring 2018

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University of Utah

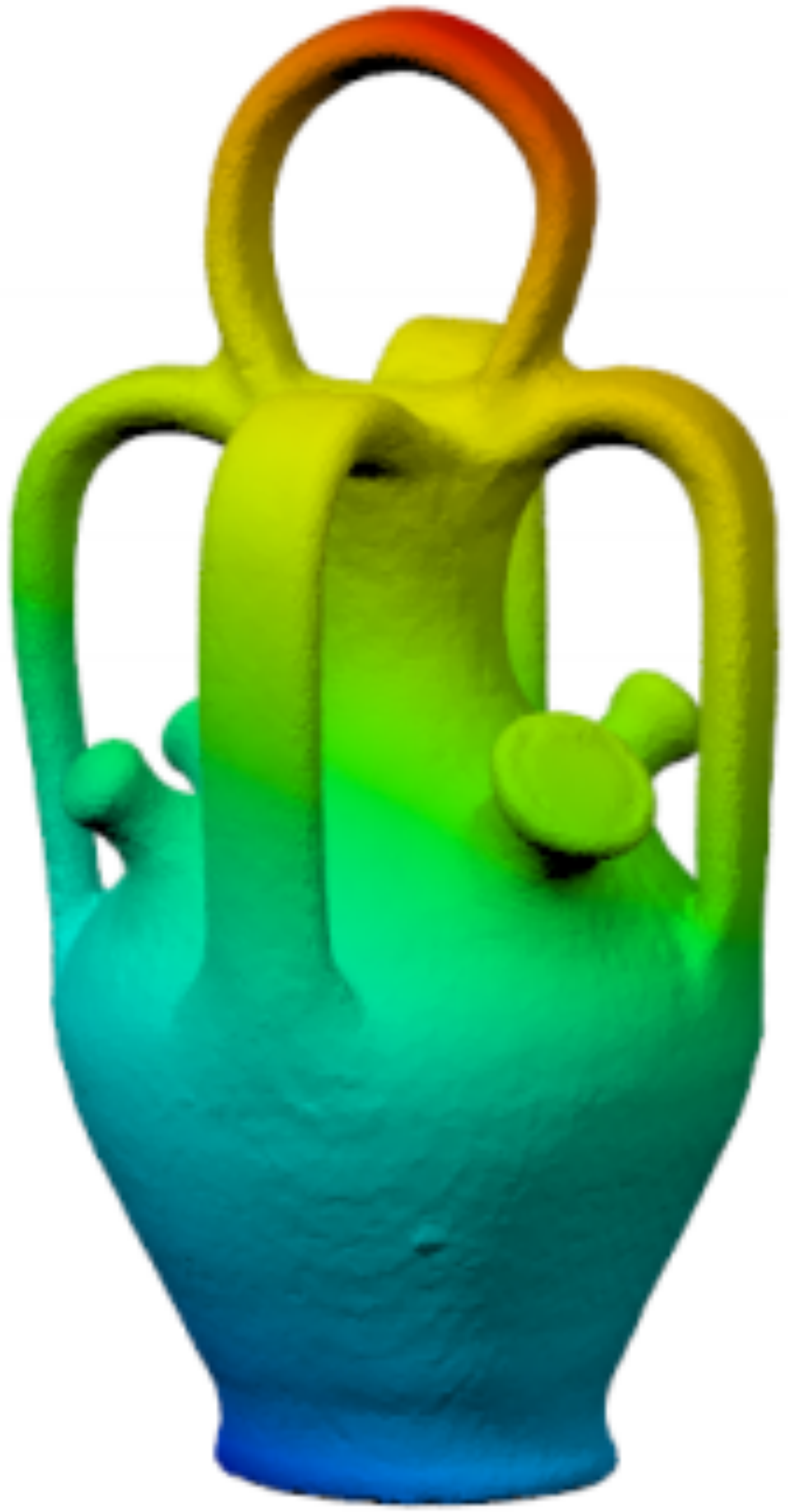
Lecture 18

Structural Inference of High-dim Data

HD+TOPO

More case studies…

- Study of low-dimensional data inspires techniques for high-dimensional data



Handles of 3D models

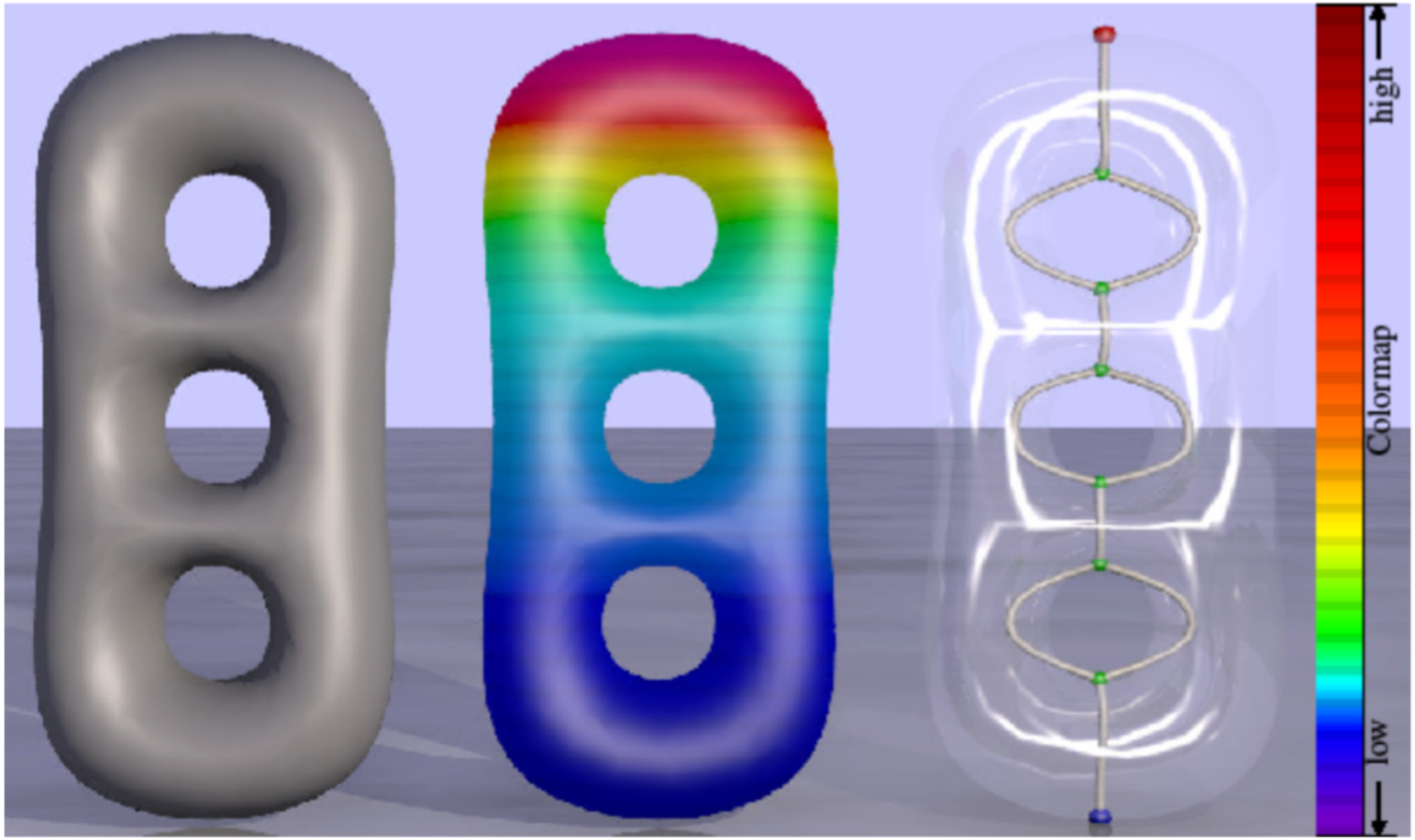
[DeyFanWang2013]

http://web.cse.ohio-state.edu/~wang.1016/papers/sig2013-loops.pdf

Review: Reeb Graph

A generalization of contour tree

Graph obtained by continuos contraction of all the contours in a scalar field, where each contour is collapsed to a distinct point.



[K. Cole-McLaughlin, H. Edelsbrunner, J. Harer, V. Natarajan and V. Pascucci, 2004]

High-level techniques

- Using Reeb Graph to find initial nontrivial loops/tunnels/handles
- Using optimization to find the ideal ones

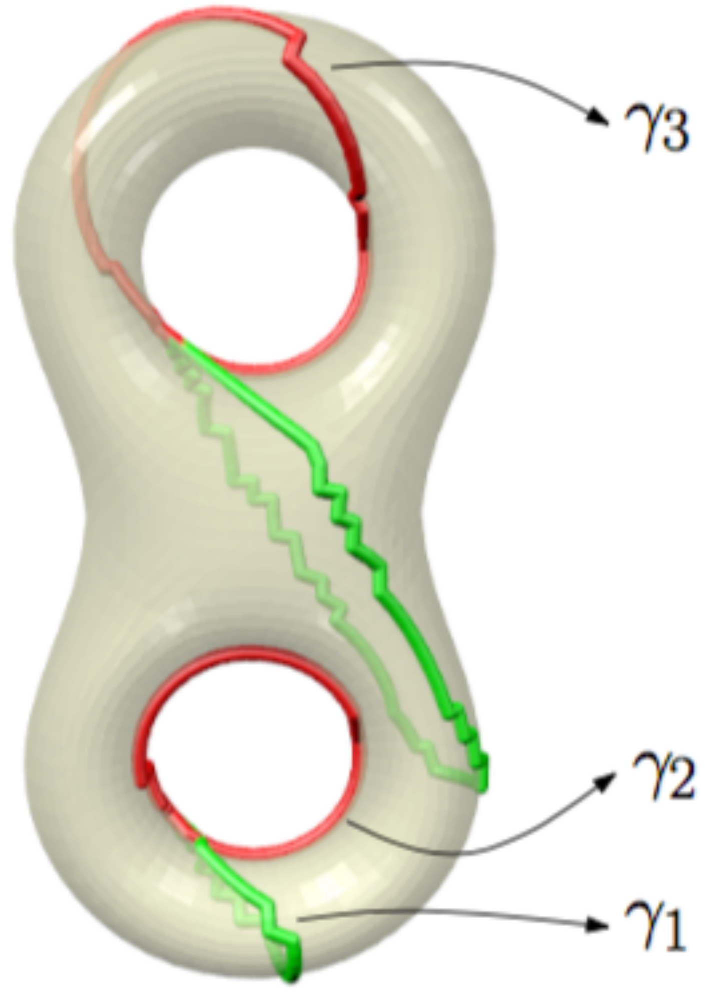


Figure 2: *γ_1 is a handle loop and γ_2 a tunnel loop. γ_3 is neither.*

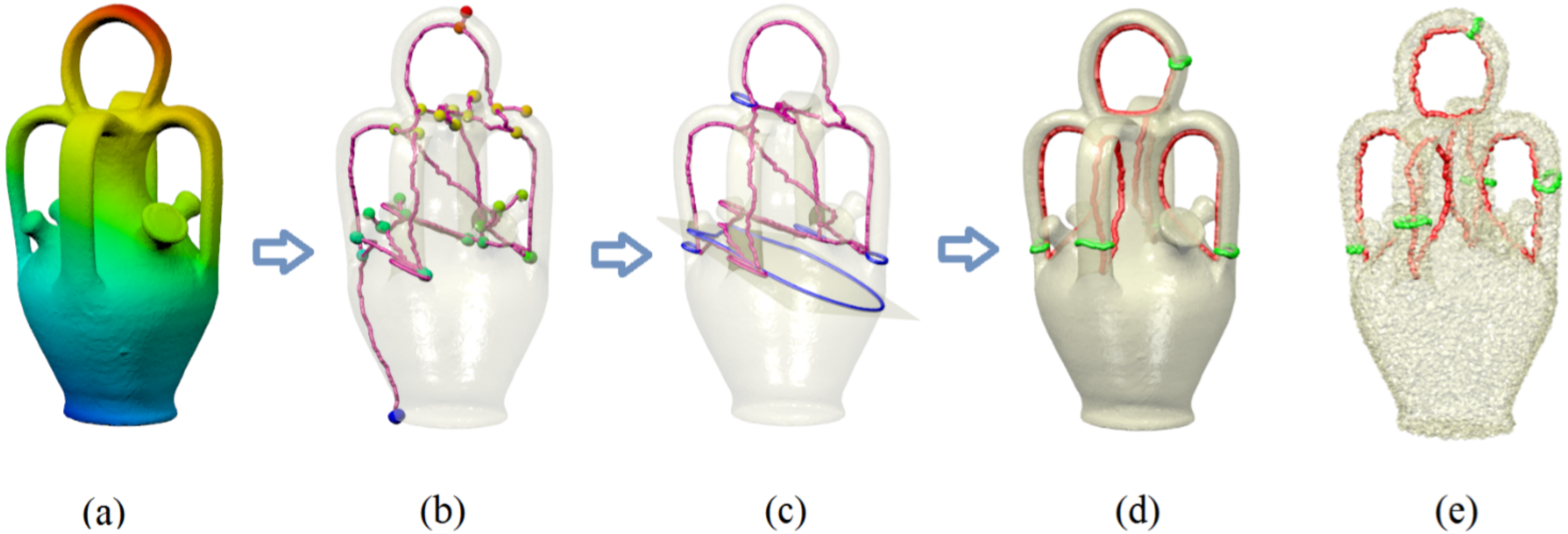


Figure 1: *(a) – (d) shows the pipeline of our algorithm: (a) The height function on the input surface. (b) Reeb graph w.r.t. the height function. (c) Initial handle and tunnel loops. (d) Final handle / tunnel loops after geometric optimization. (e) The output is stable under noise.*

Fast processing with original mesh

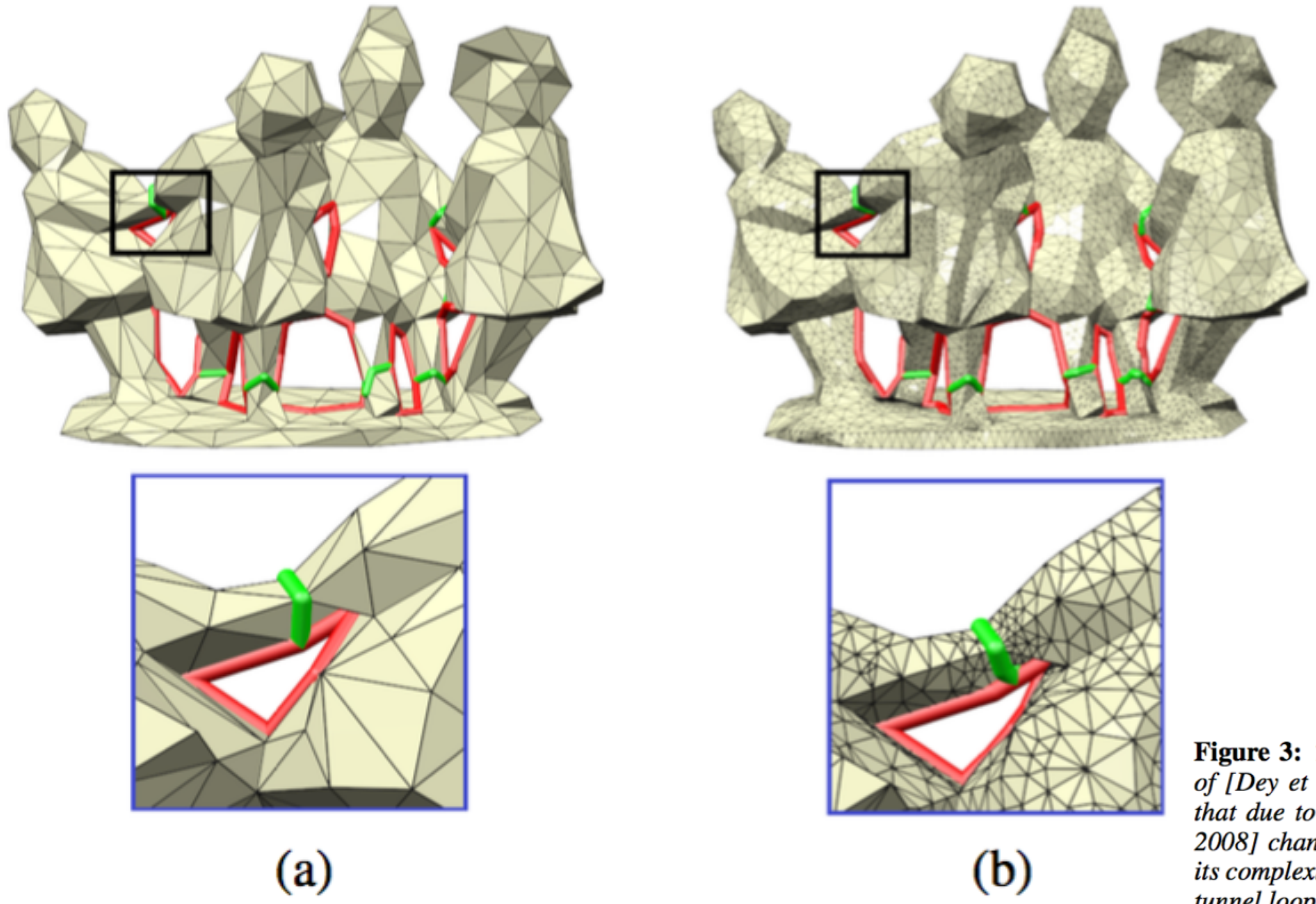


Figure 3: *The output of (a) our algorithm and (b) the algorithm of [Dey et al. 2008] for an input mesh with 449 vertices. Note that due to the tetrahedral meshing, the algorithm of [Dey et al. 2008] changes the input surface mesh and significantly increases its complexity to 7943 vertices. Our algorithm obtained handle and tunnel loops of good quality from the original sparse mesh.*

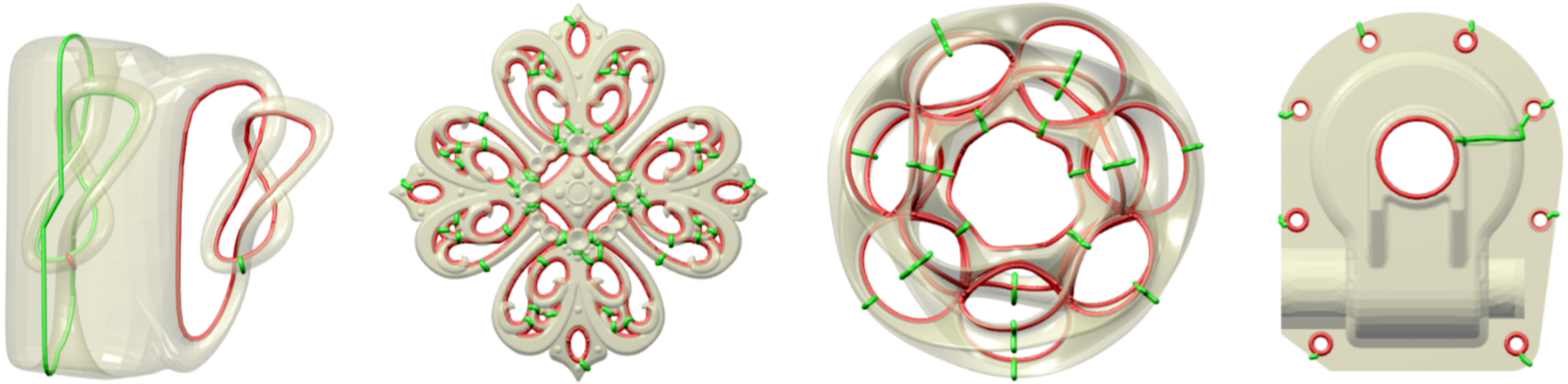
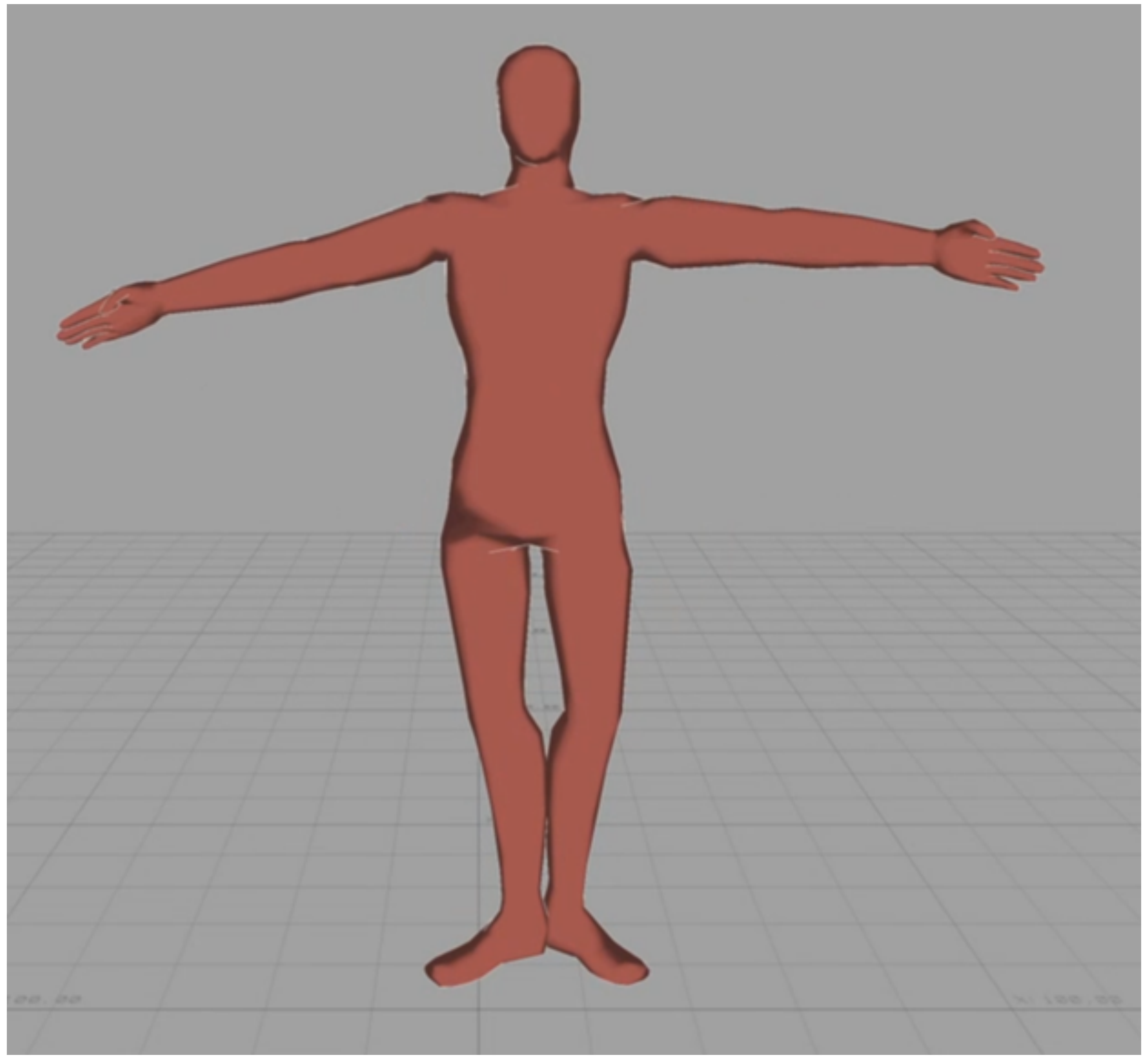


Figure 6: *Various examples. From left to right:* KNOTTY-CUP, FILIGREE, HEPTOROID *and* CASTING.

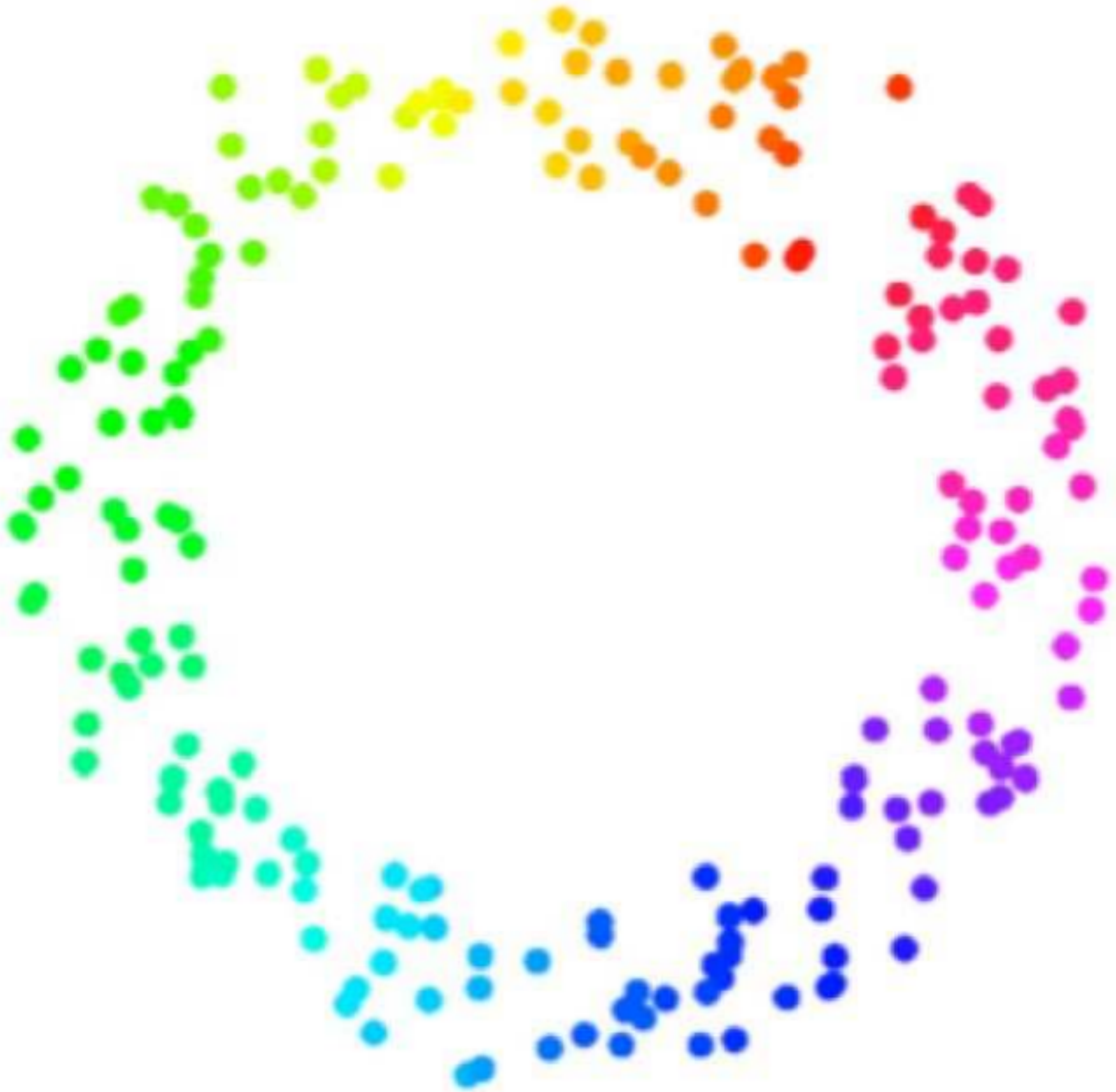


Circular and Branching Structures in High-dim

[WangSummaPascucci2011]

http://www.sci.utah.edu/~beiwang/publications/Branching_BeiWang_2011.pdf

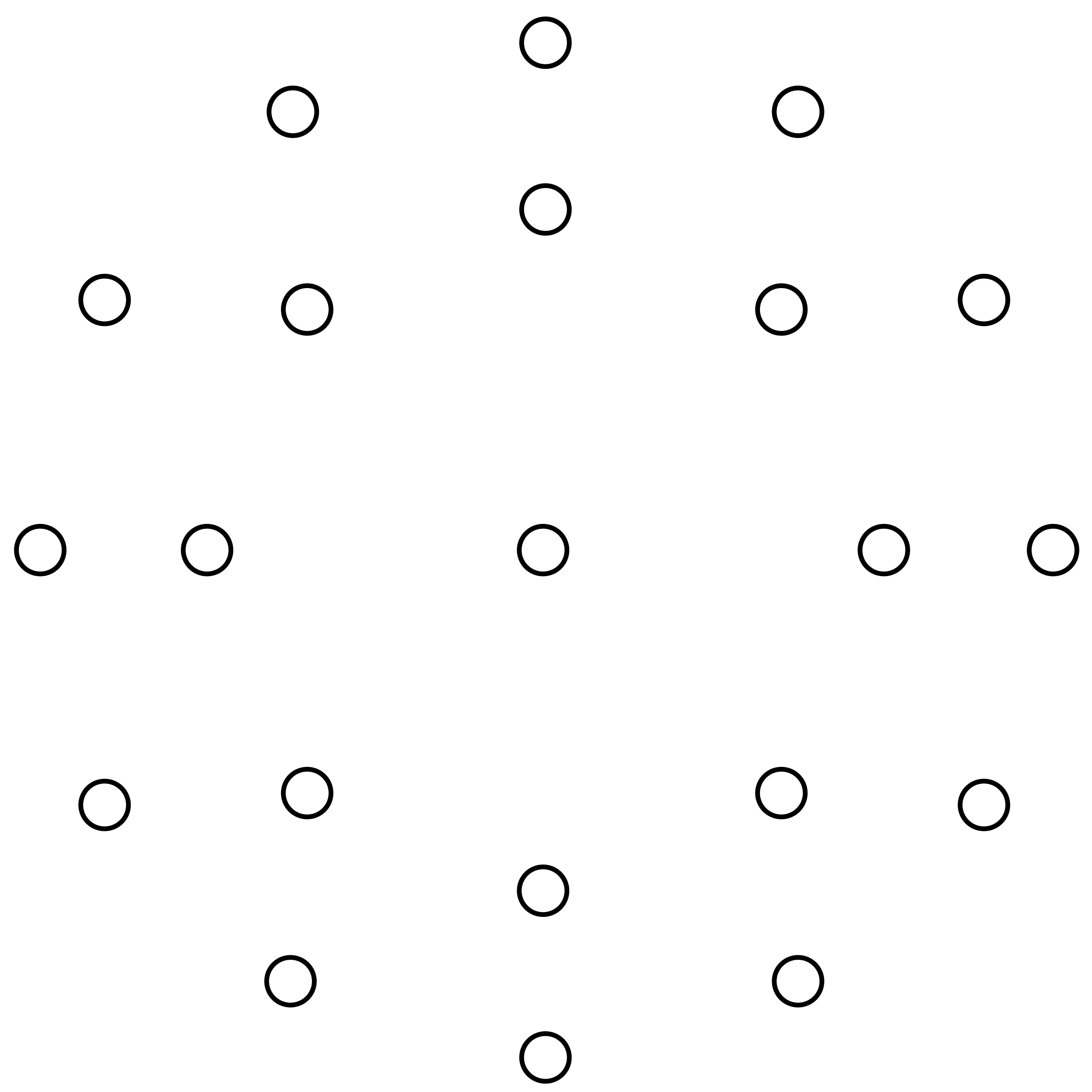
Inferring circular structure



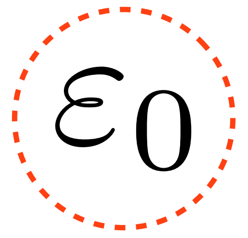
High-level techniques

- Persistent homology (PH), persistent cohomology (dual version)
- Circular parametrization

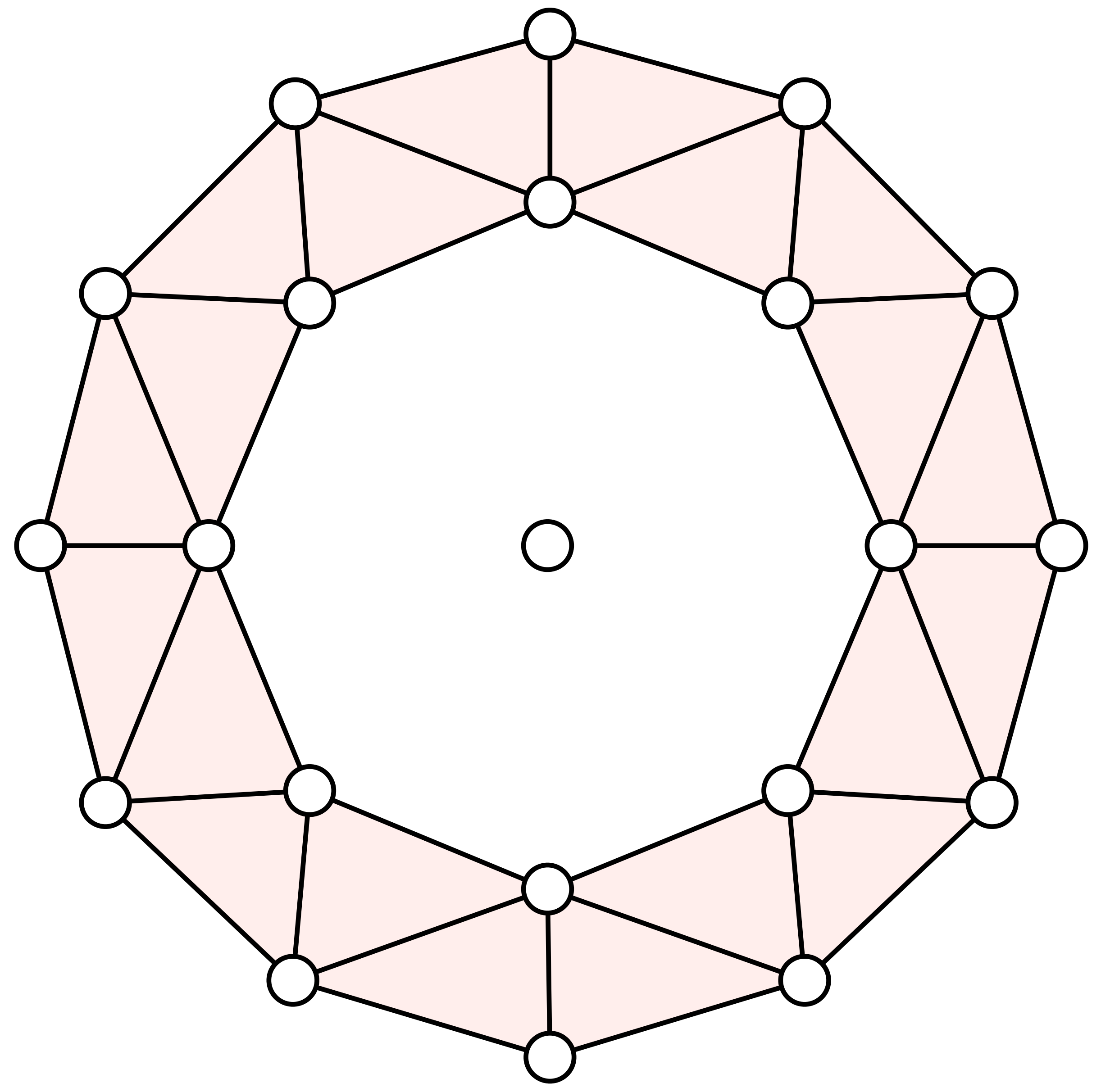
PH and parametrization

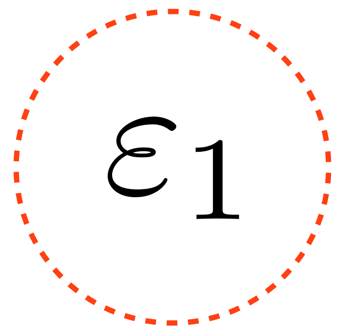


$Rips(X, \varepsilon_0)$



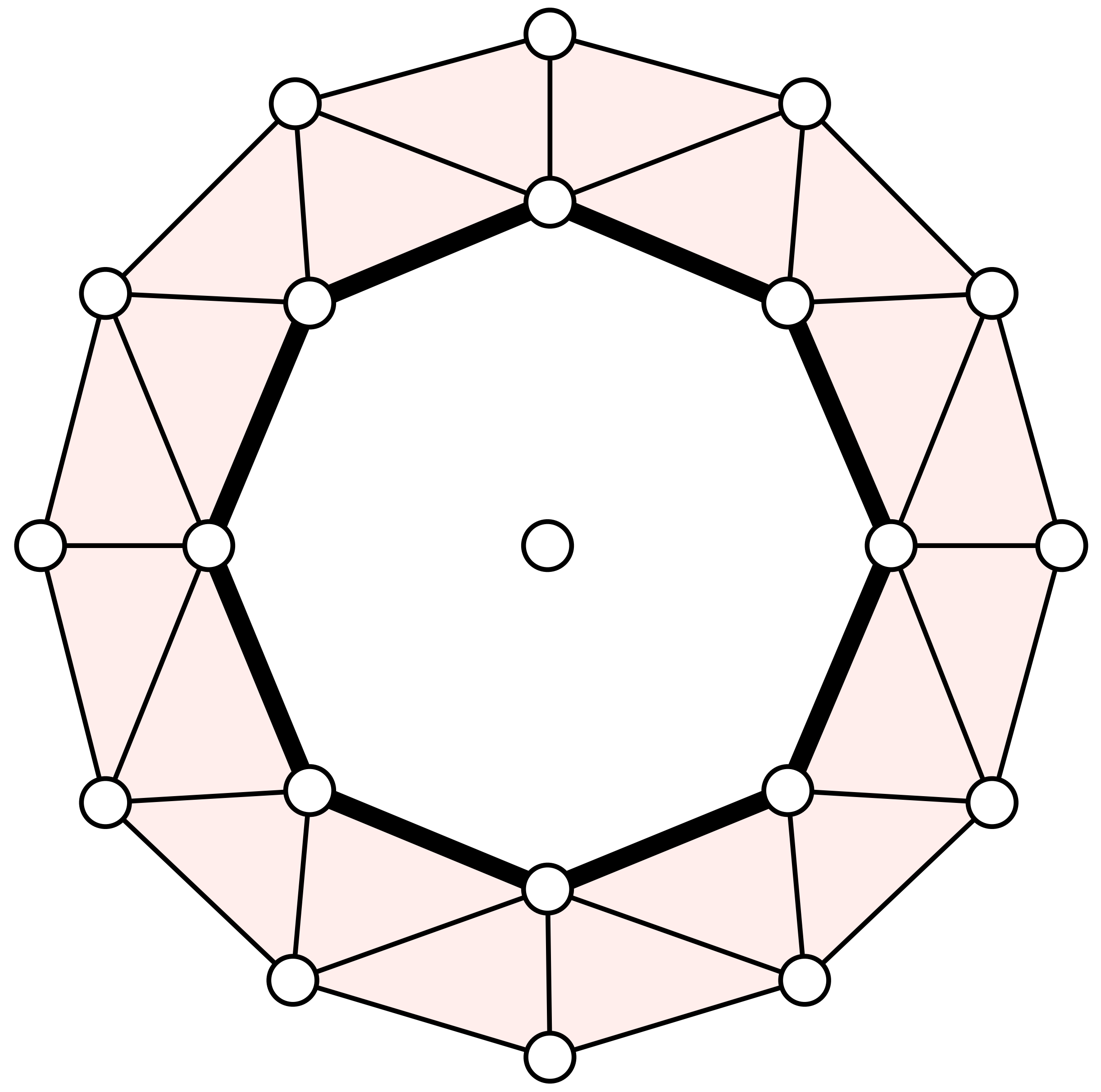
PH and parametrization

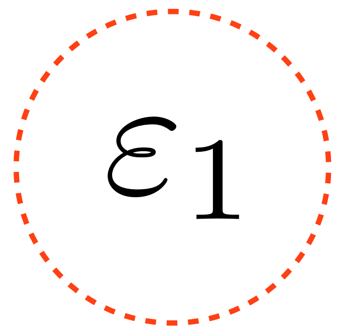




$$Rips(X, \varepsilon_0) \subseteq Rips(X, \varepsilon_1)$$

PH and parametrization





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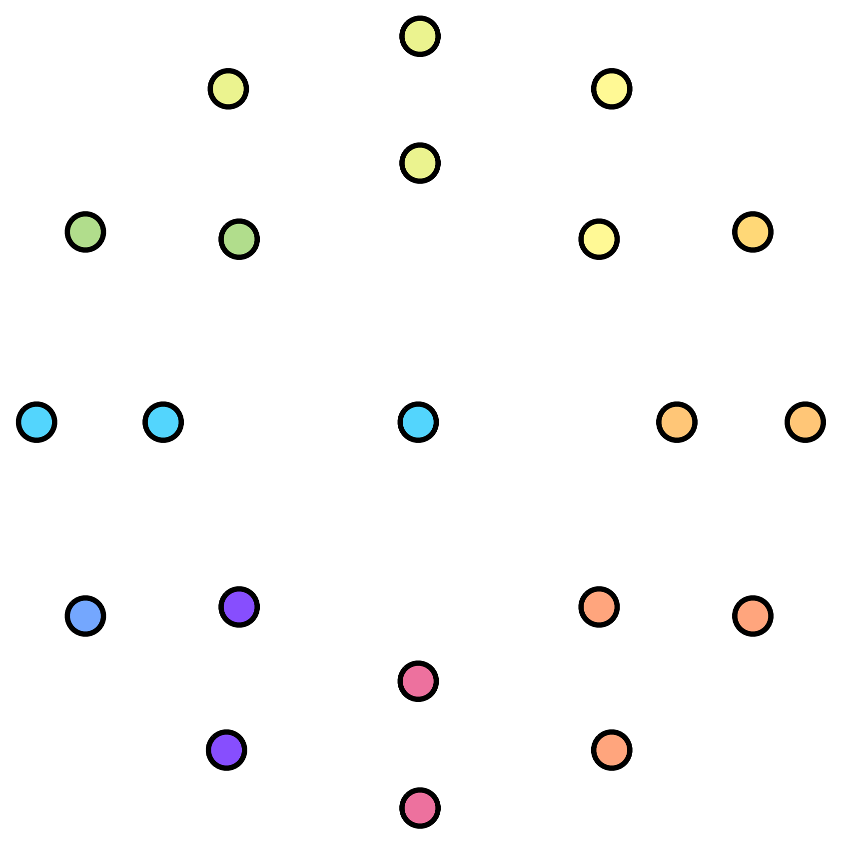
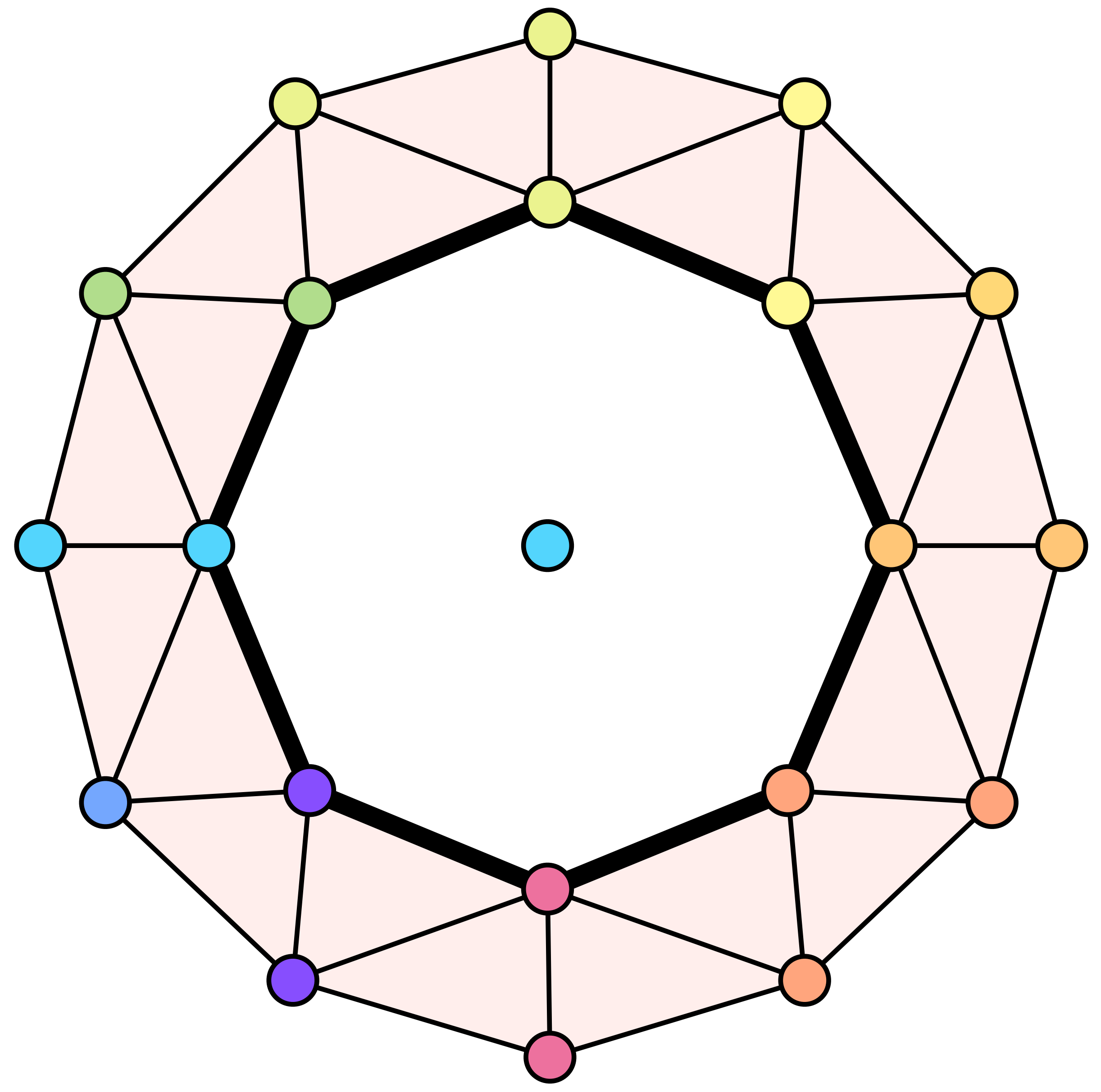
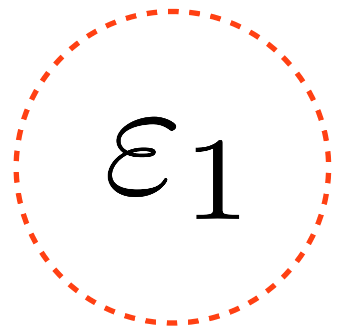
PH and parametrization



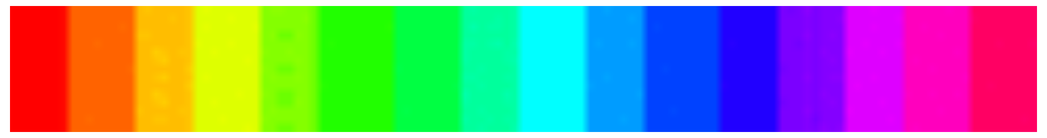
Born: ε_1



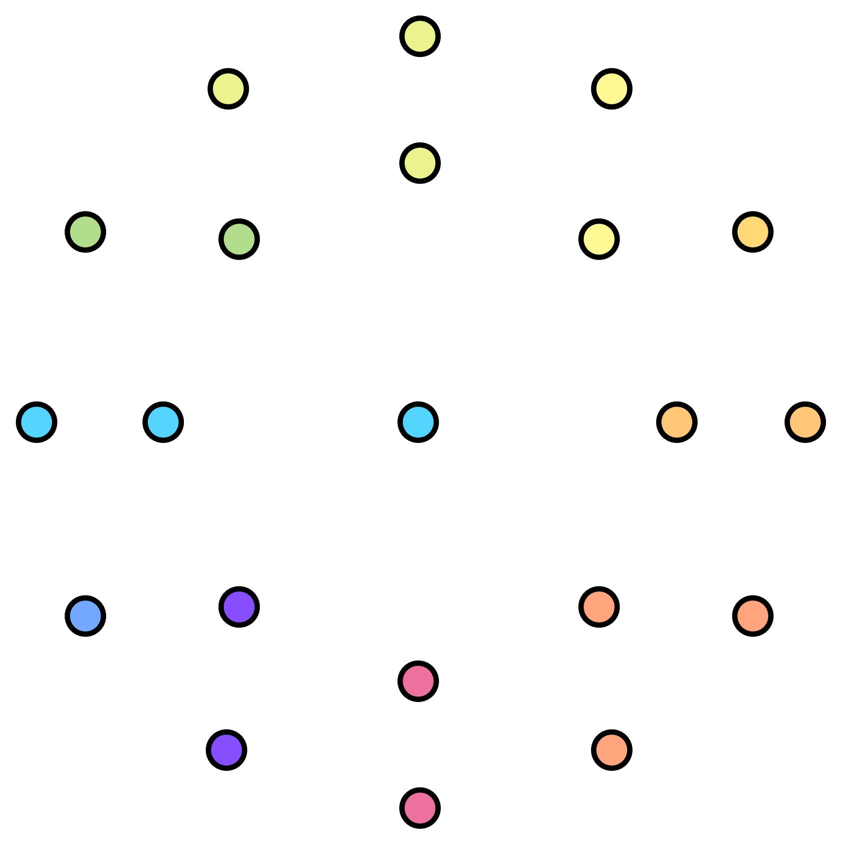


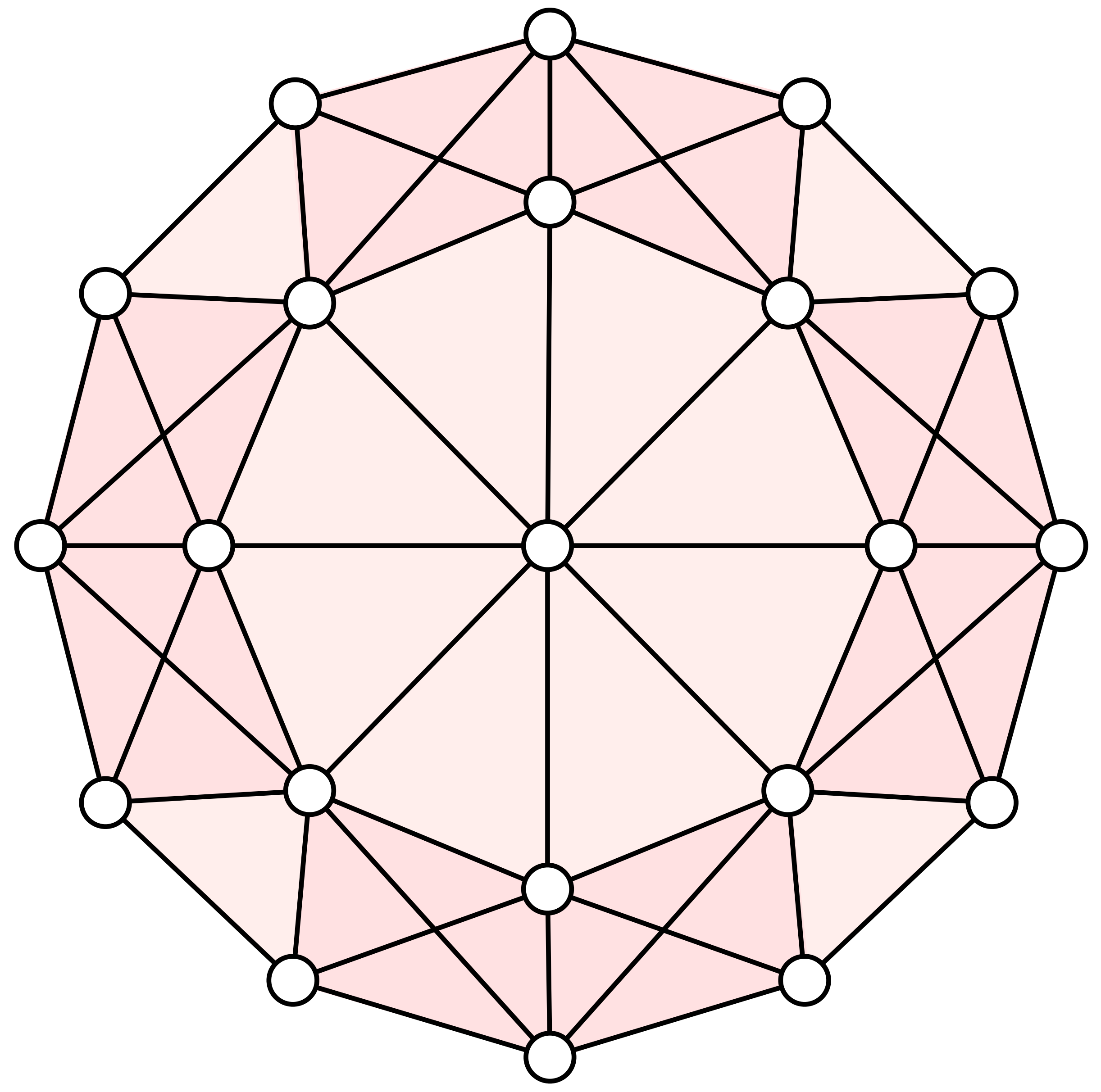
$$Rips(X, \varepsilon_0) \subseteq Rips(X, \varepsilon_1)$$

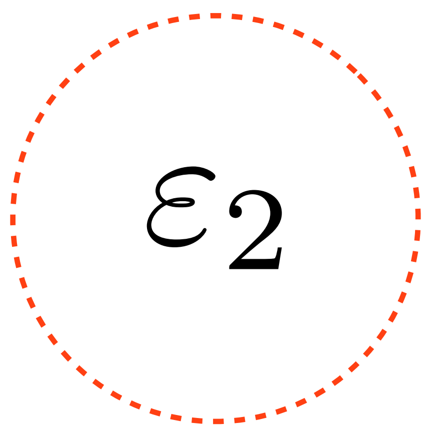
Parameter Space:



PH and parametrization



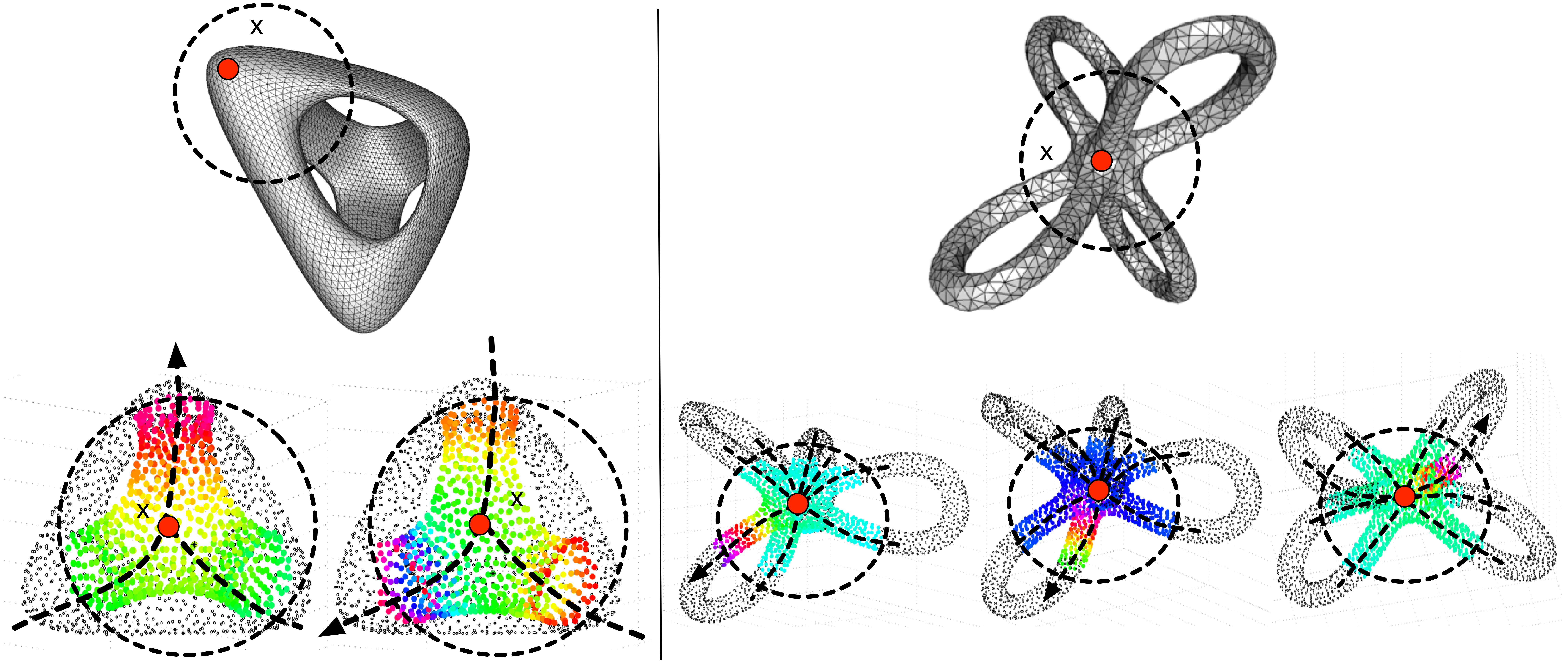




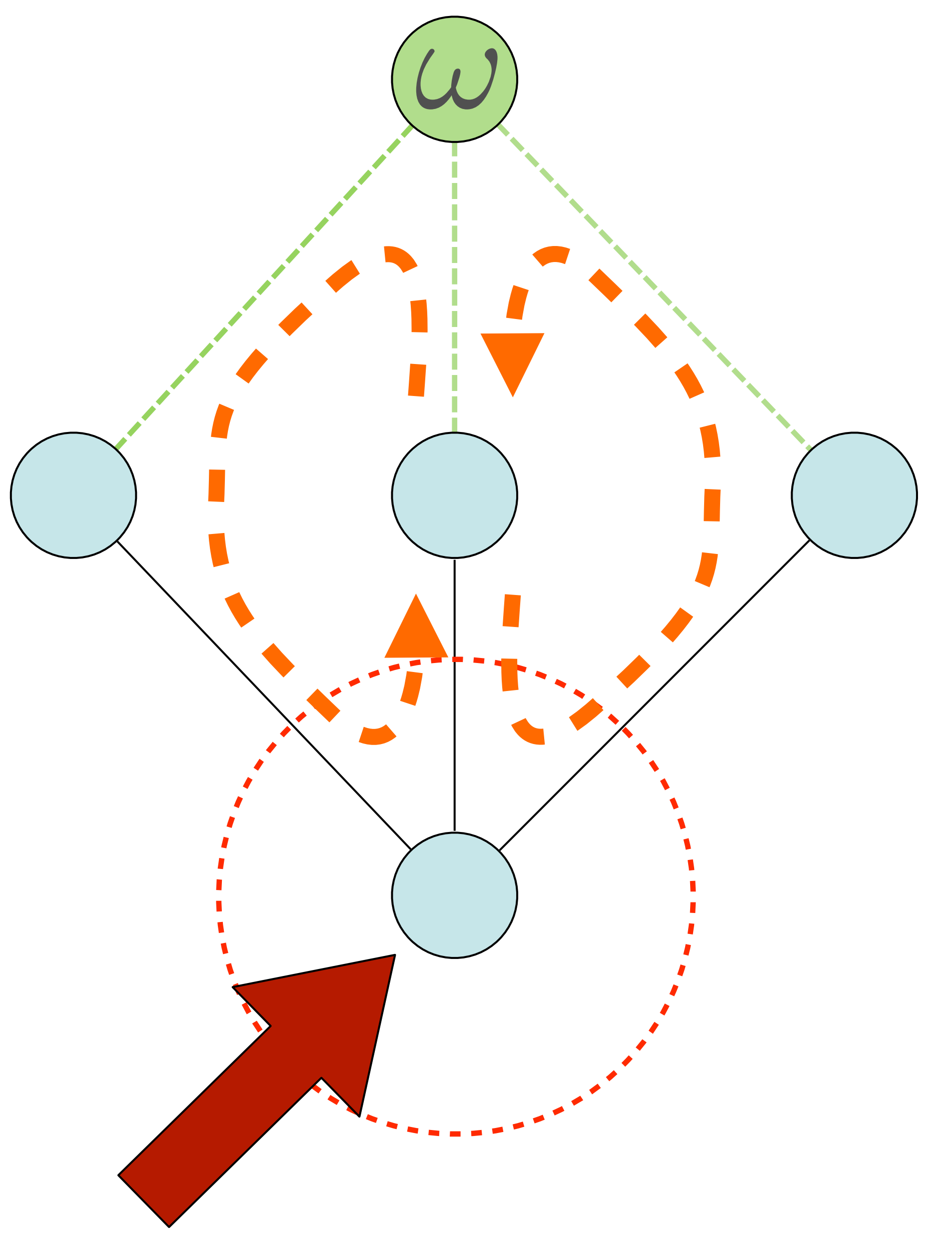
Born: ε_1 Died: ε_2
Persistence: $\varepsilon_2 - \varepsilon_1$

$$Rips(X, \varepsilon_0) \subseteq Rips(X, \varepsilon_1) \subseteq Rips(X, \varepsilon_2)$$

Inferring branching structure



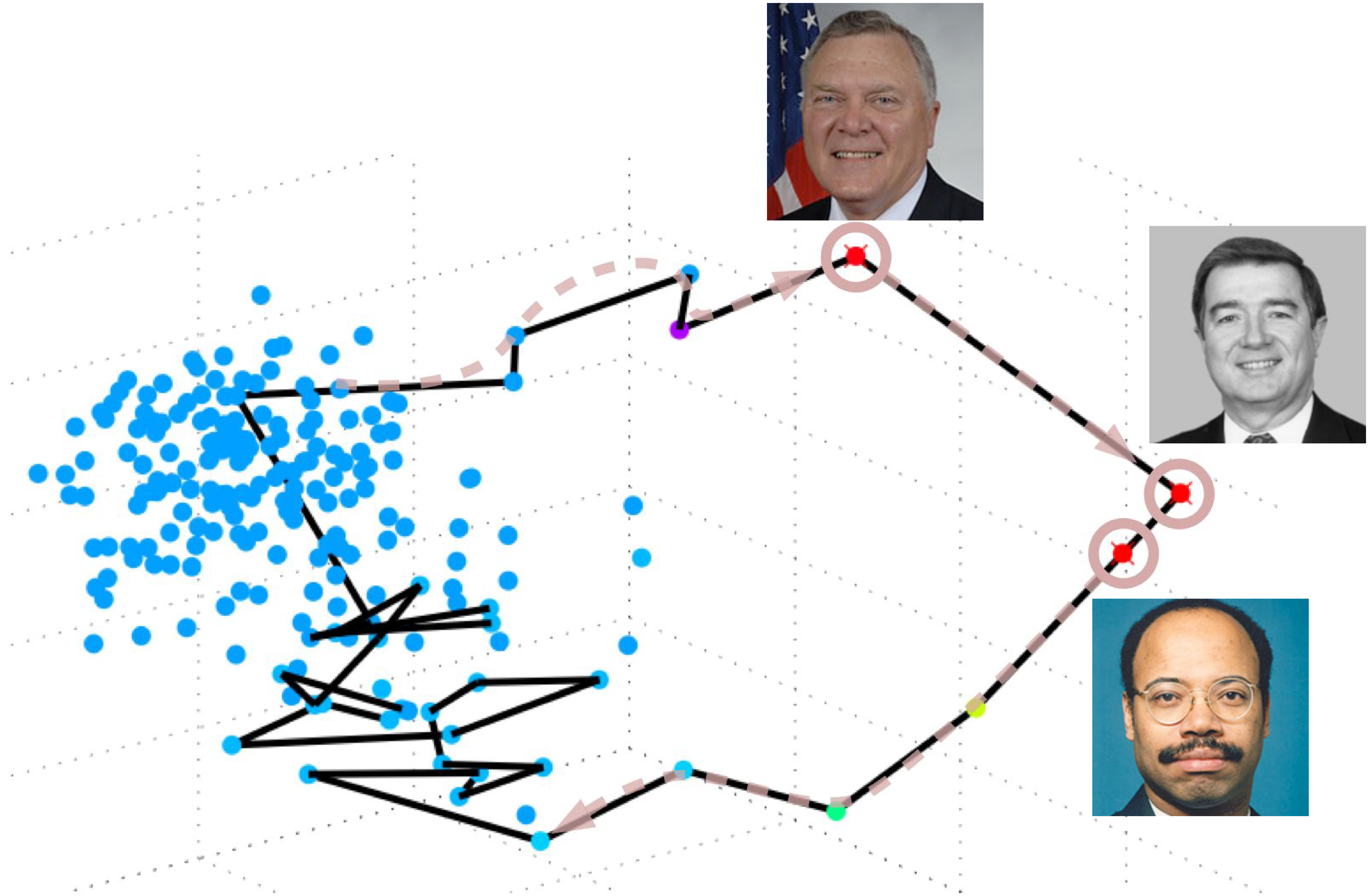
Branching and parametrization



Given a neighborhood around a point, attach simplicies which cross the neighborhood threshold to a dummy vertex ω.

In this way, we turn local branching features into circular structures.

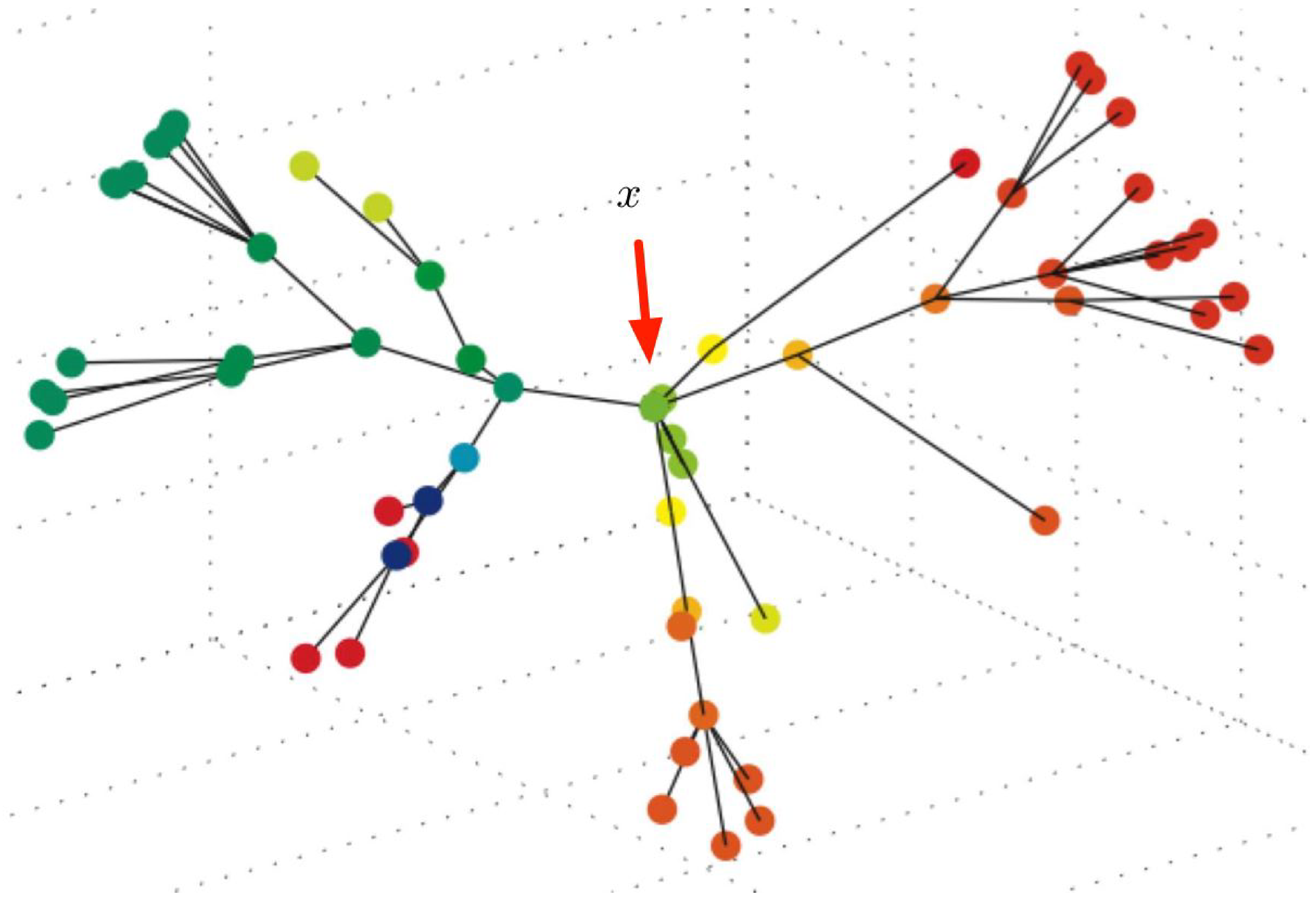
Voting Data



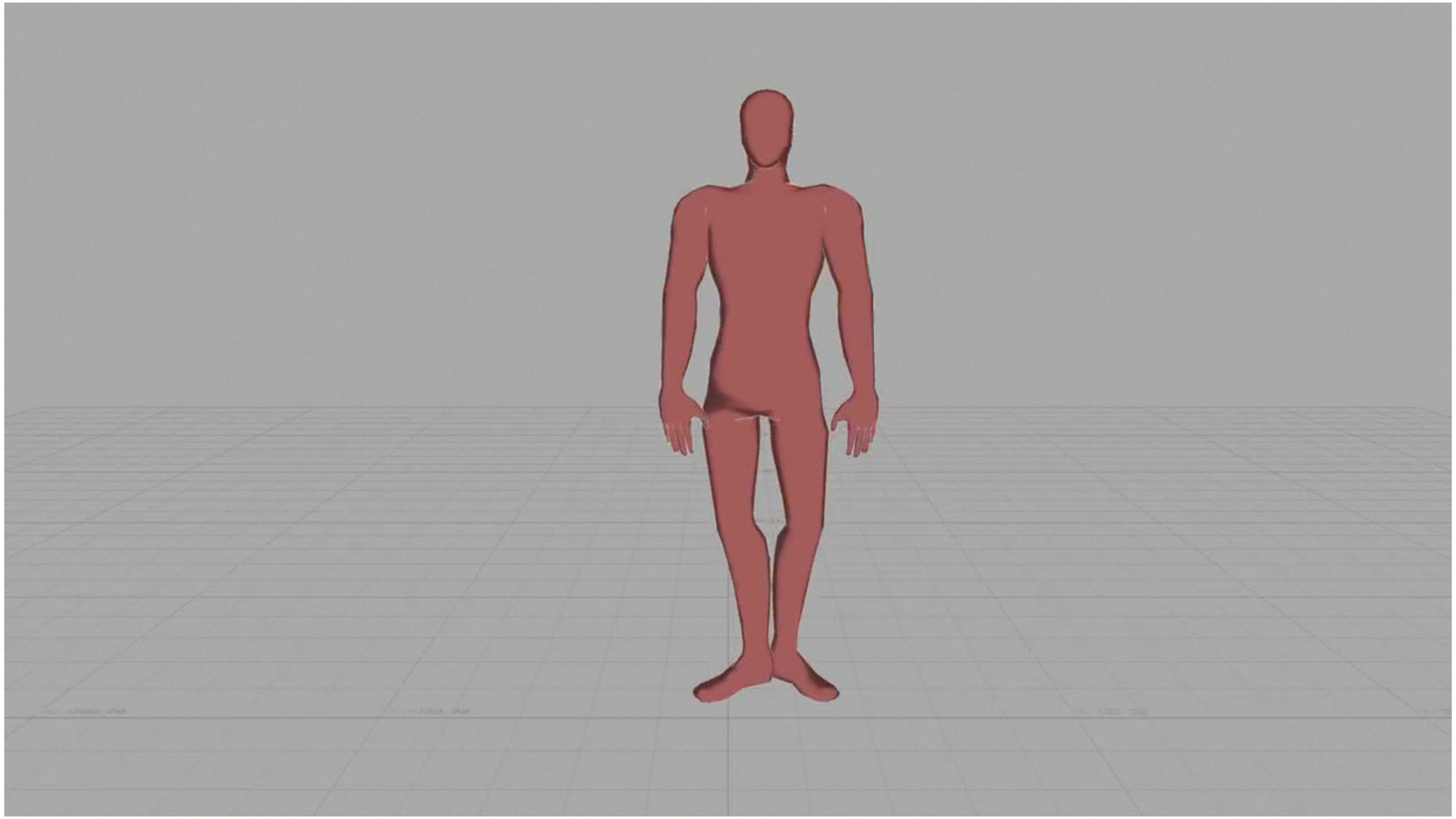
1995 House of Representatives Voting Record
885 votes (dimension)
205 Democratic congresspeople (points)
Record: (Yea/Nay/Absent)
94.27 seconds to compute
(92.15 Rips, 1.76 Persistence)

Outliers: switched party or resigned

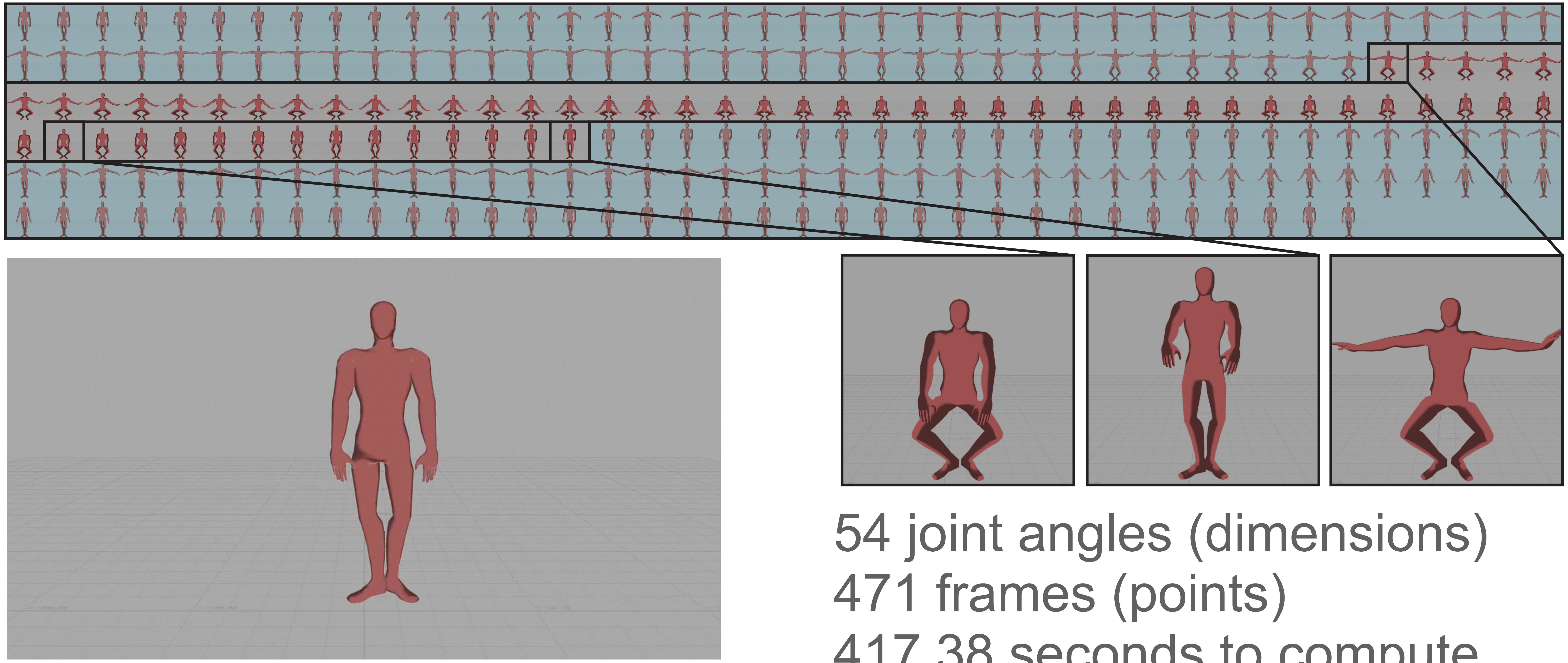
Virus Data



1045 nucleotides (dimensions)
58 mutated genetic sequences (points)
0.09 seconds to compute
(0.05 Rips, 0.02 Persistence)

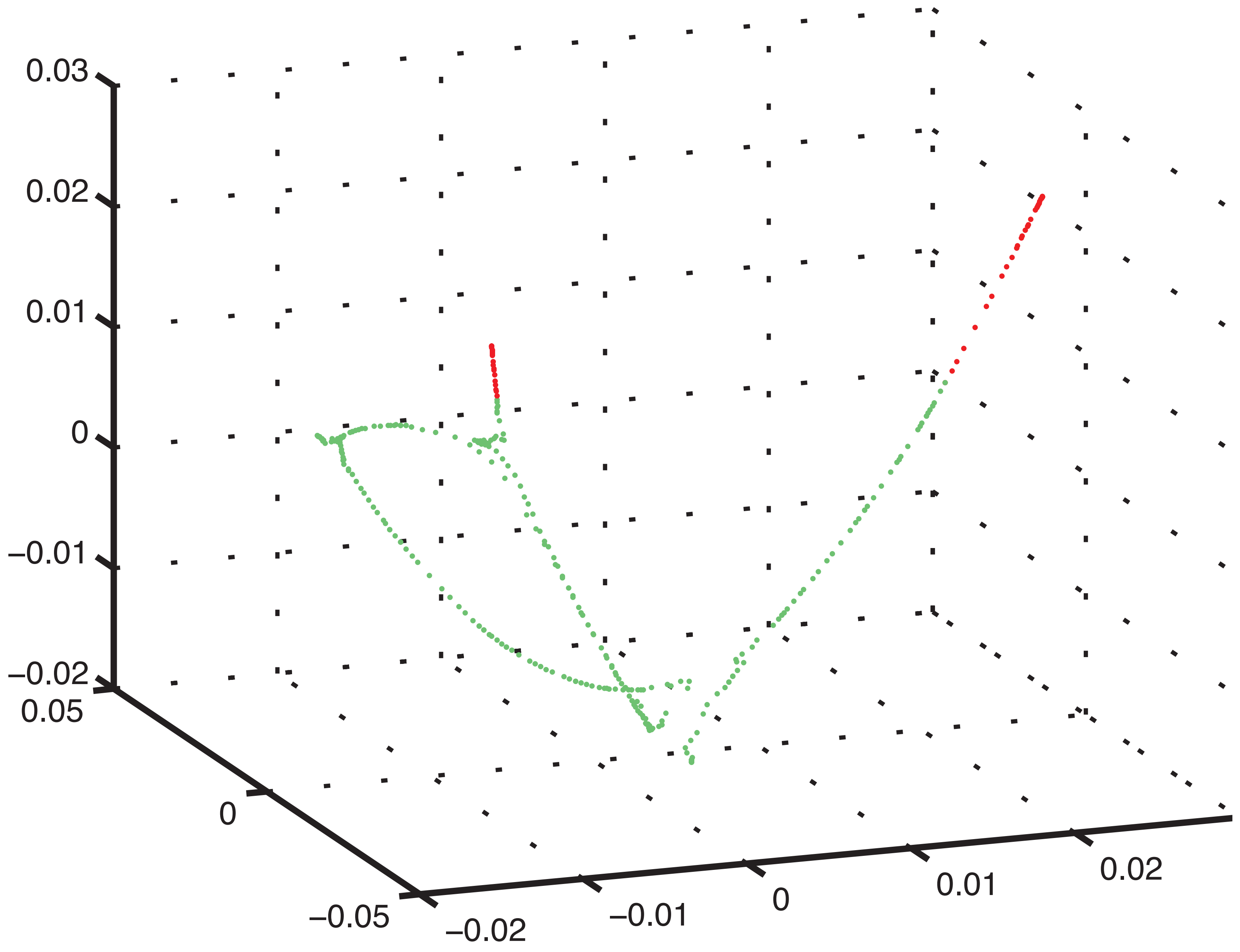


Motion Capture: Ballet

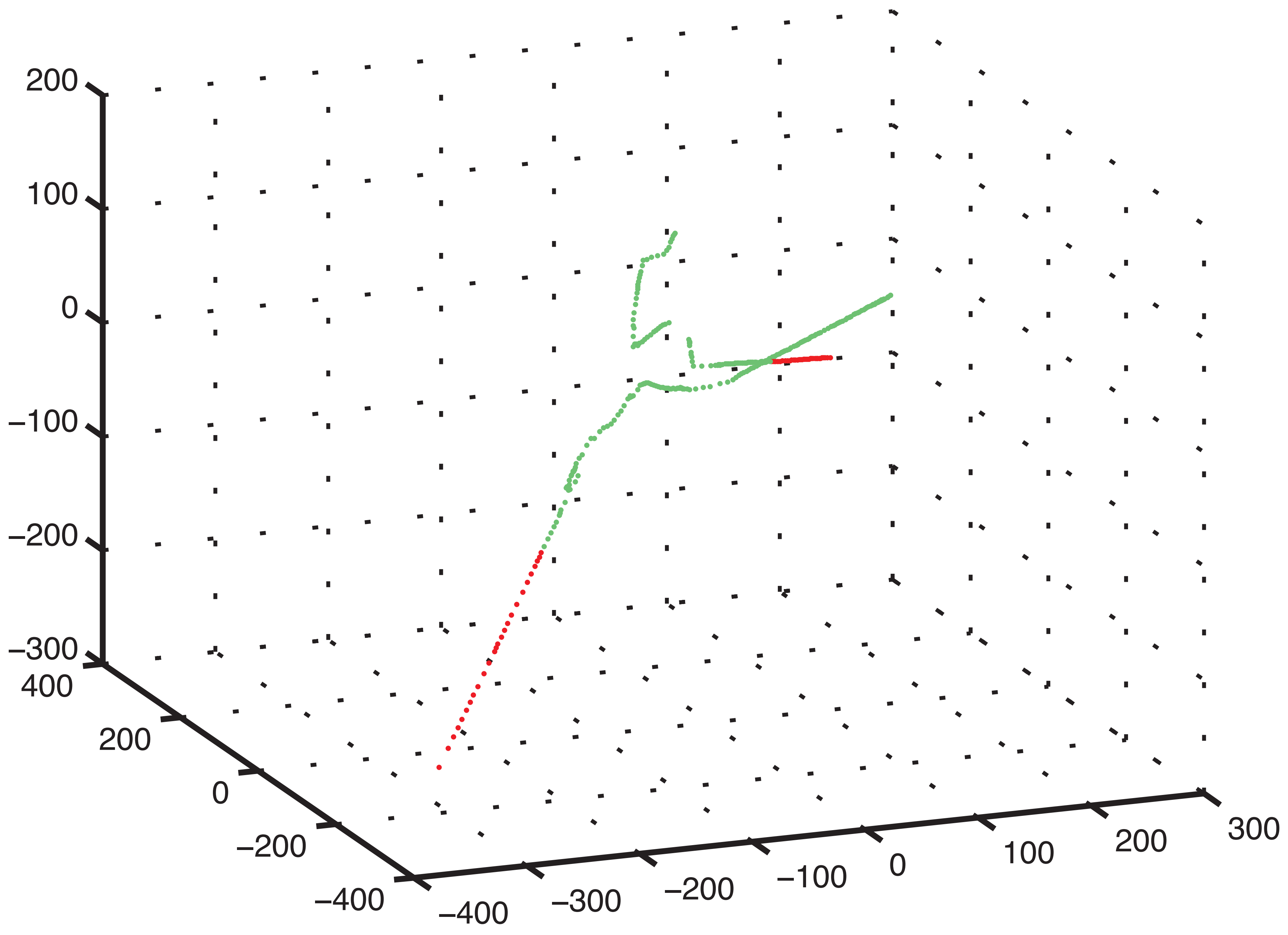


54 joint angles (dimensions)
471 frames (points)
417.38 seconds to compute
(363.67 Rips, 30.47 Persistence)

Motion Capture: Ballet

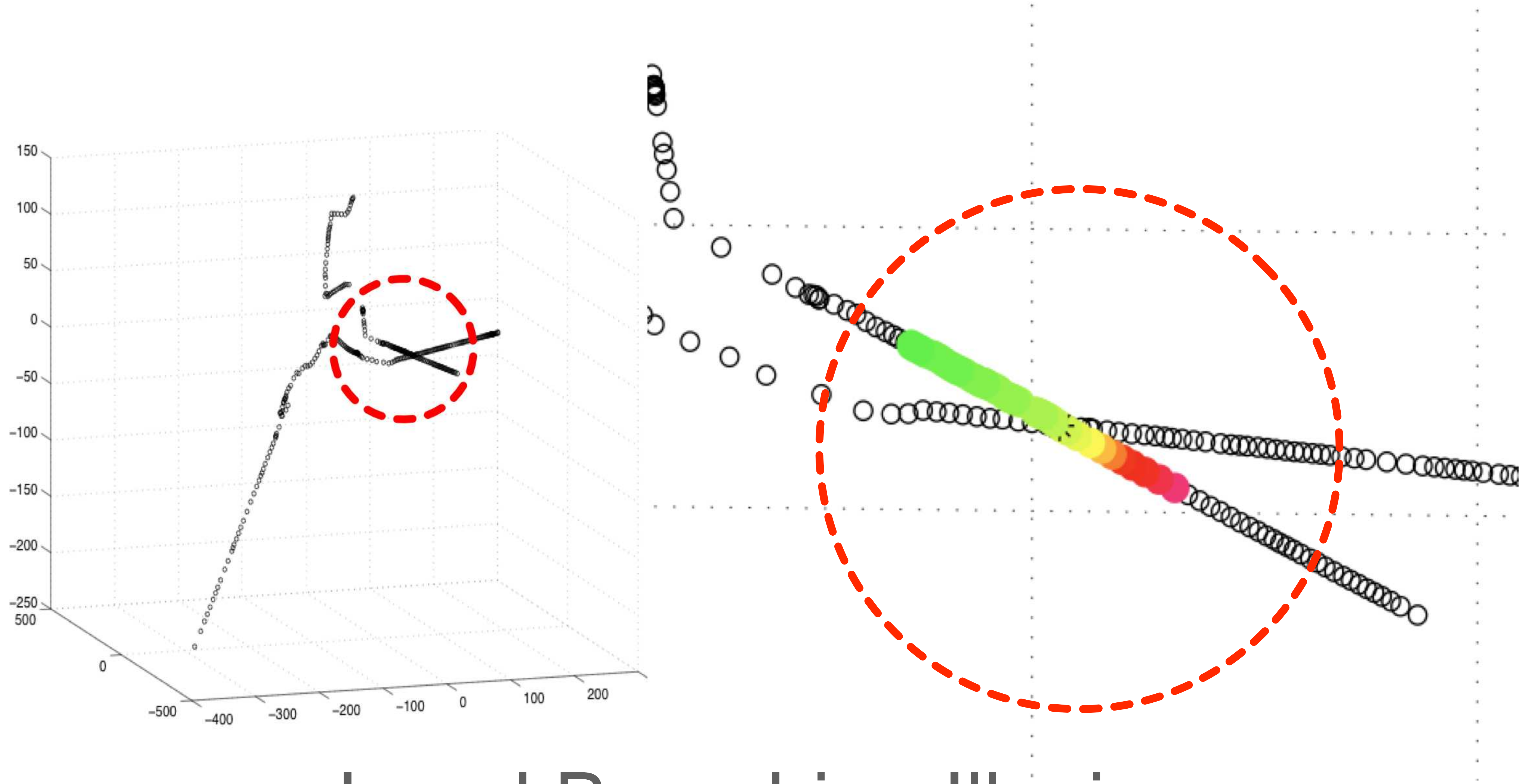


Laplacian Eigenmaps



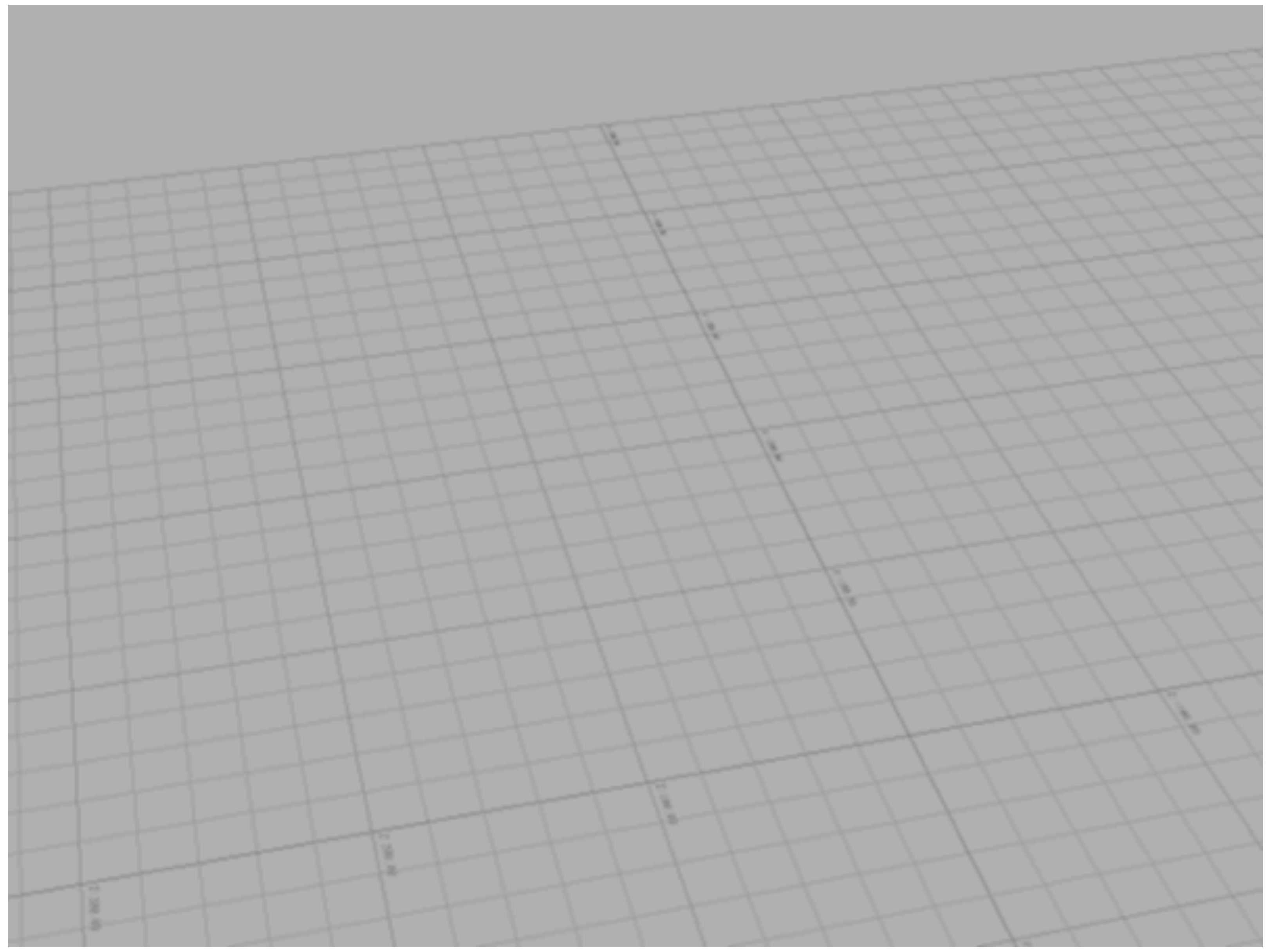
3D Isomap

Motion Capture: Ballet

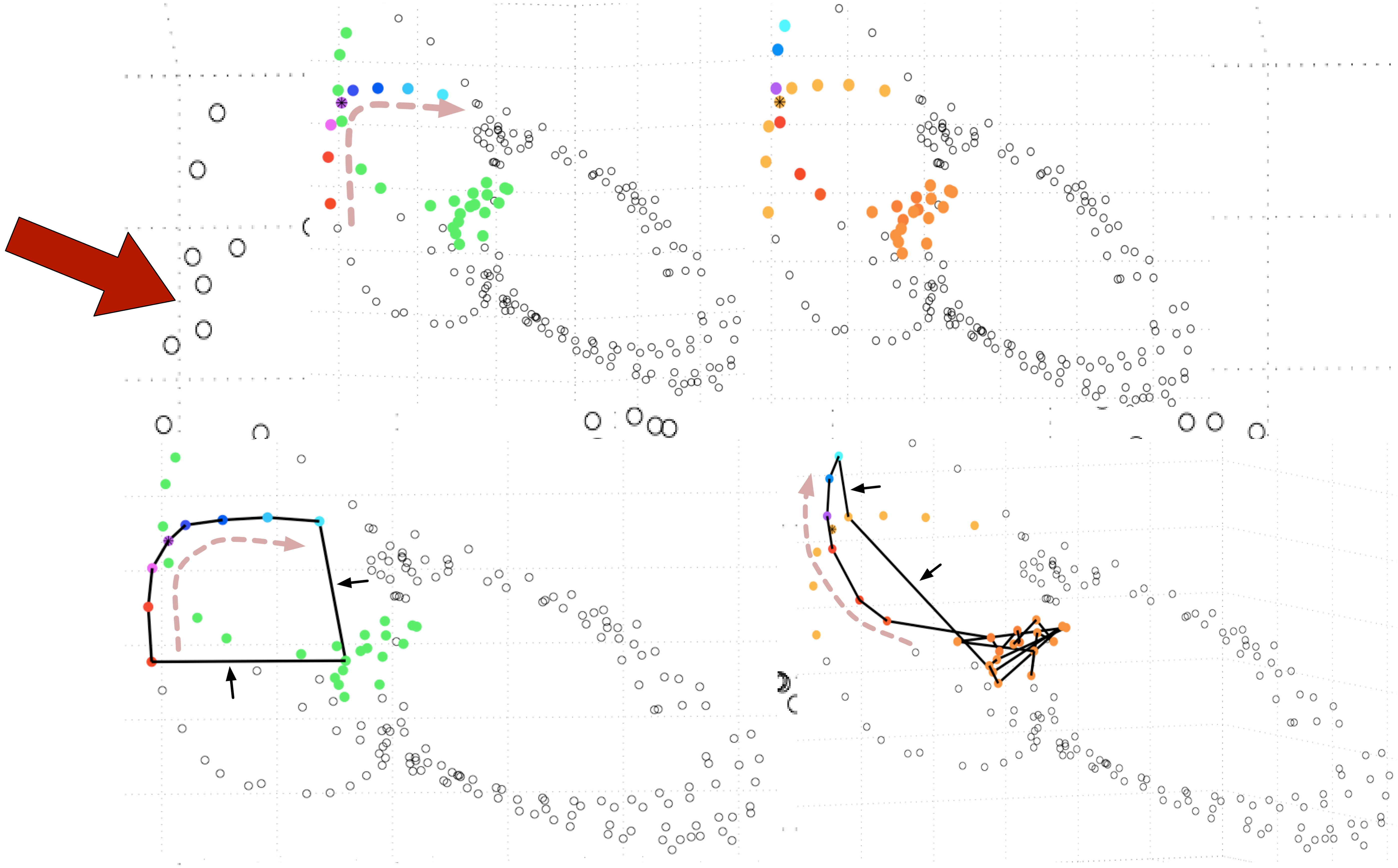


Local Branching Illusion

Motion Capture - Walk/Hop/Walk



66 joint angles (dimensions)
189 frames (points)
0.08 seconds to compute
(0.08 Rips)



Thanks!

Any questions?

You can find me at: **beiwang@sci.utah.edu**

CREDITS

Special thanks to all people who made and share these awesome resources for free:

- Presentation template designed by Slidesmash
- Photographs by unsplash.com and pexels.com
- Vector Icons by Matthew Skiles

Presentation Design

This presentation uses the following typographies and colors:

Free Fonts used:

http://www.1001fonts.com/oswald-font.html

https://www.fontsquirrel.com/fonts/open-sans

Colors used