Computing with 3D Geometry

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Medical Implants + AM Day

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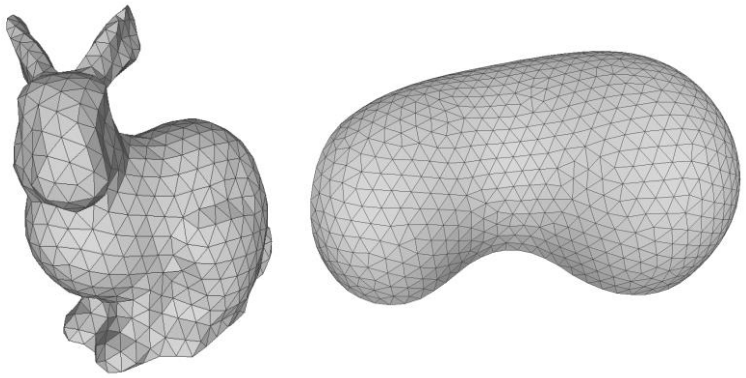
My group

Research agenda

Build mathematical and algorithmic tools
that allow artists, scientists and engineers
to easily create and process
3D geometric data

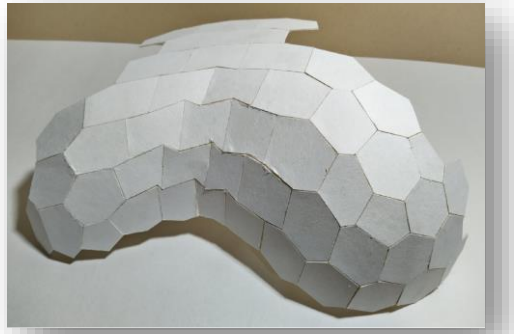
Example projects

Input:
Digital shape



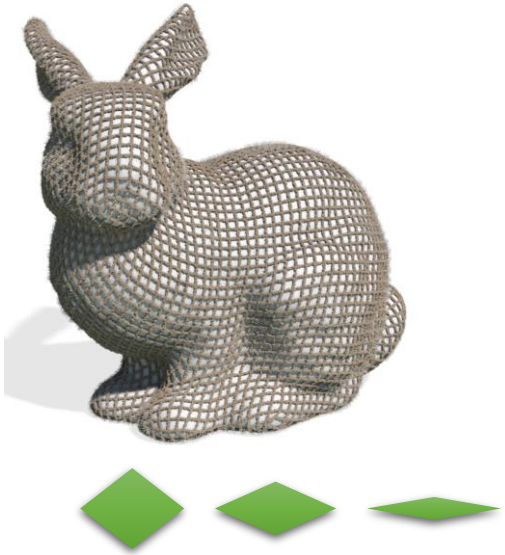
Output: Realization using…

net fabric

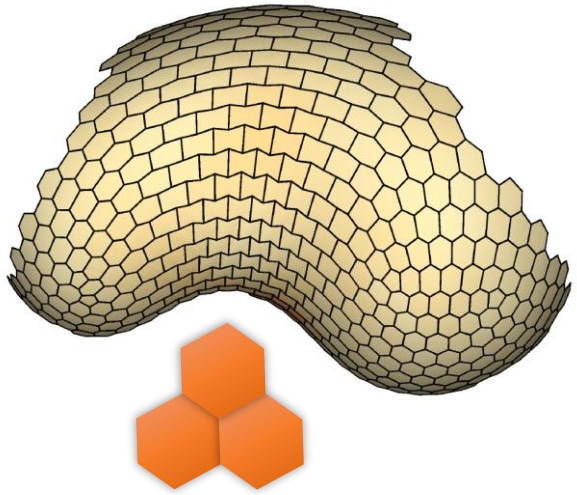


cardboard

Technical challenge: Re-mesh using…

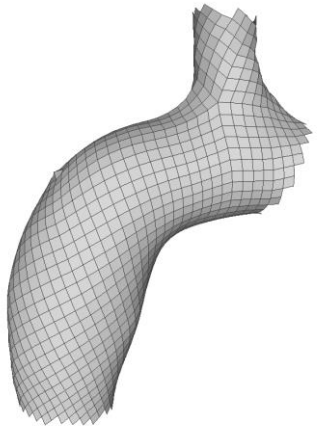


Equal edge-length quads



flat hexagons

Can be used for:



Personalized stents

Architecture

References

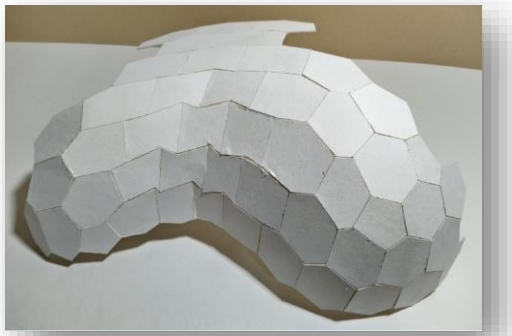
- “Chebyshev Nets from Commuting PolyVector Fields”,

  Andrew O. Sageman-Furnas, Albert Chern, Mirela Ben-Chen and Amir Vaxman.
  ACM Transactions on Graphics 38(6), SIGGRAPH Asia 2019.

- “PH-CPF: Planar Hexagonal Meshing Using Coordinate Power Fields”,

  Kacper Pluta, Michal Edelstein, Amir Vaxman and Mirela Ben-Chen

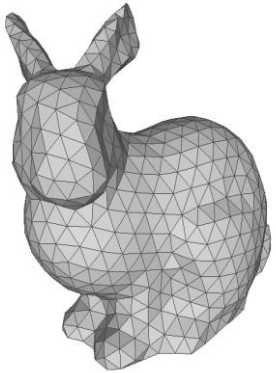
  ACM Transactions on Graphics to appear, SIGGRAPH 2021.



Example projects

Input:

Digital shape + PDE

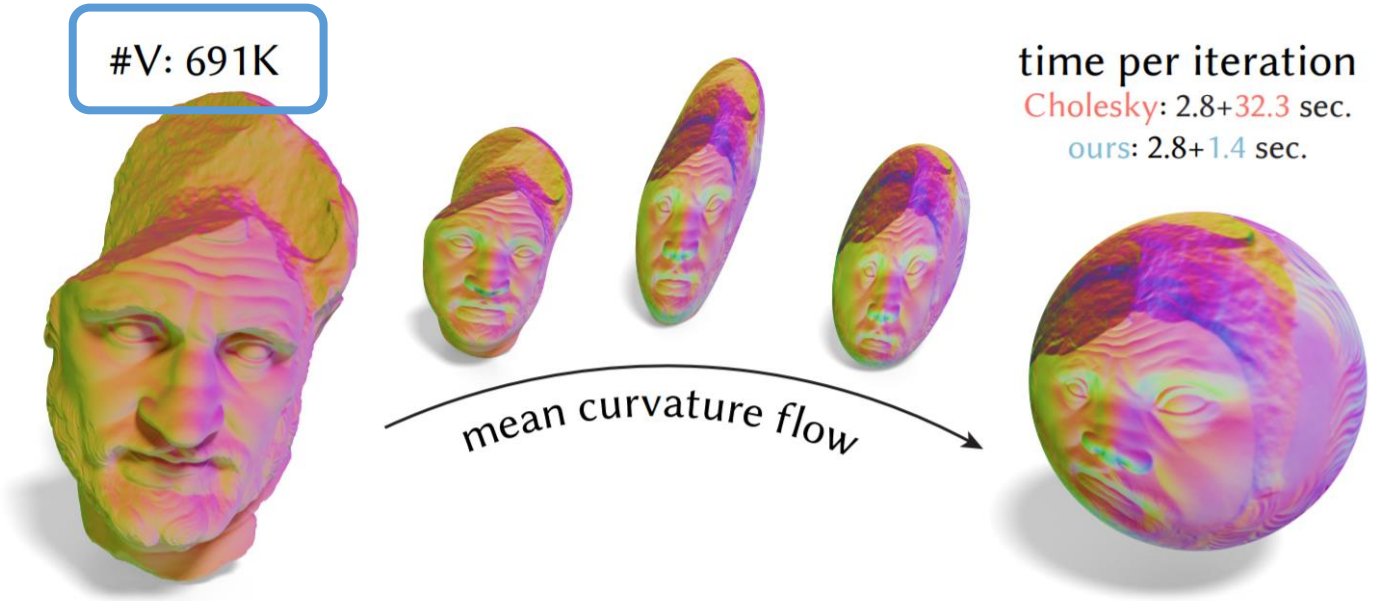


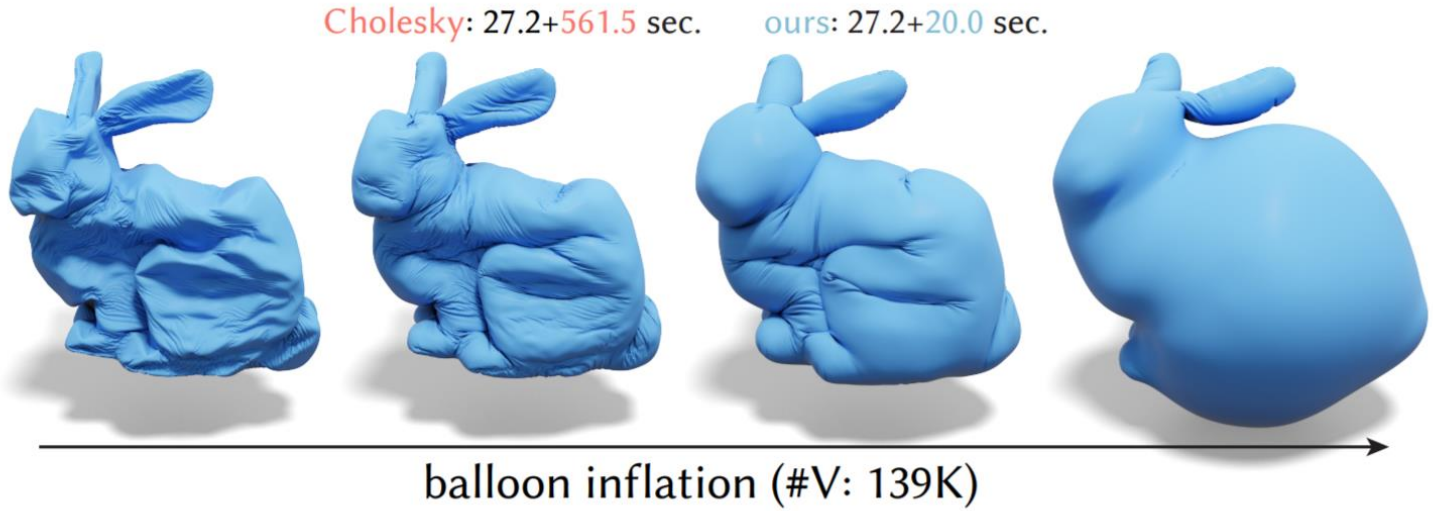
Output:

geometric flow

Technical challenge:

very large meshes





"Surface Multigrid via Intrinsic Prolongation",
Hsueh-Ti Derek Liu, Jiayi Eris Zhang, Mirela Ben-Chen and Alec Jacobson, ACM Transactions on Graphics to appear, SIGGRAPH 2021.

Balloon Simulation [Skouras et al. 2012]

#V: 139K

Cholesky

27.2+561.5 sec

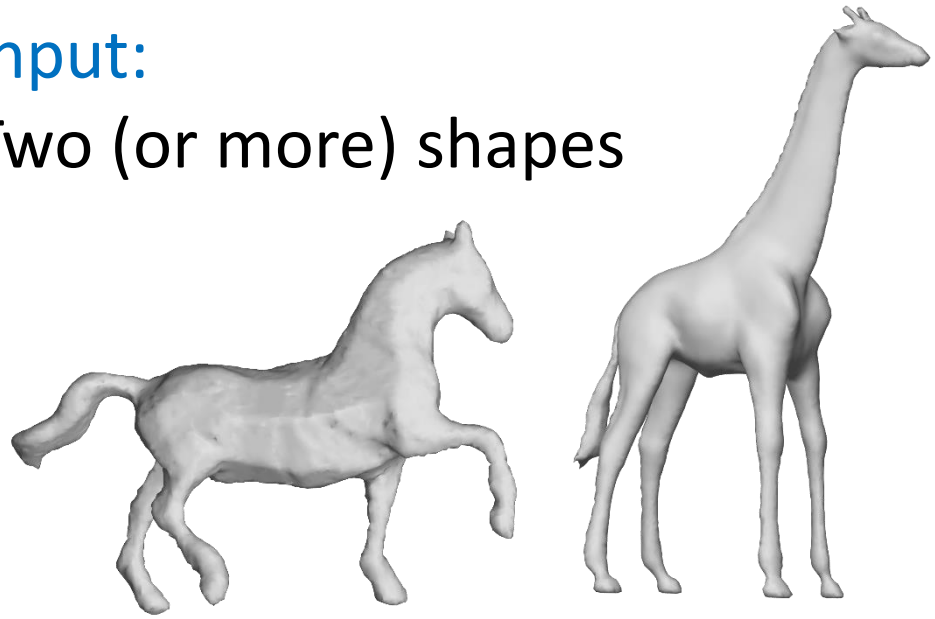
Ours

27.2+20.0 sec.

Example projects

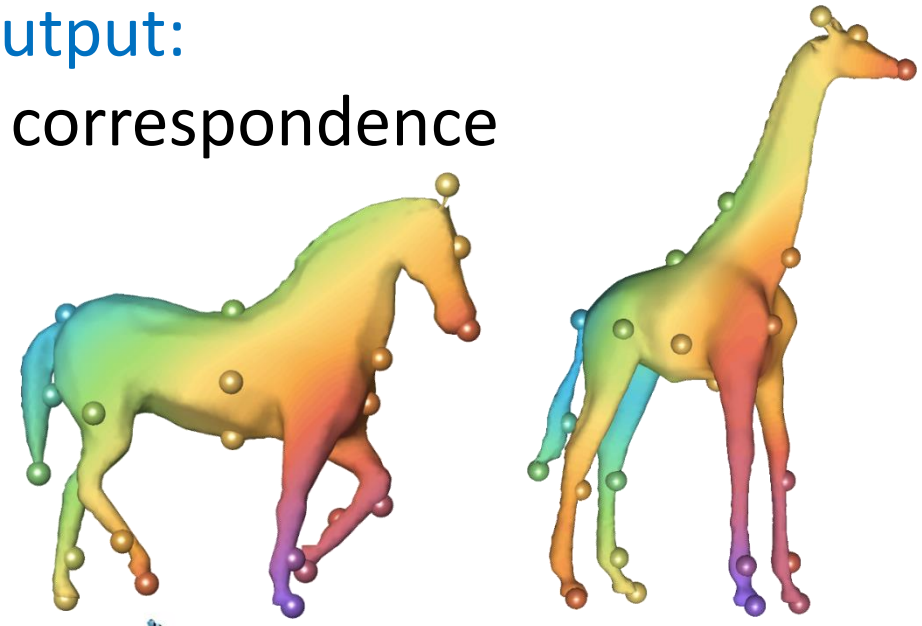
Input:

Two (or more) shapes



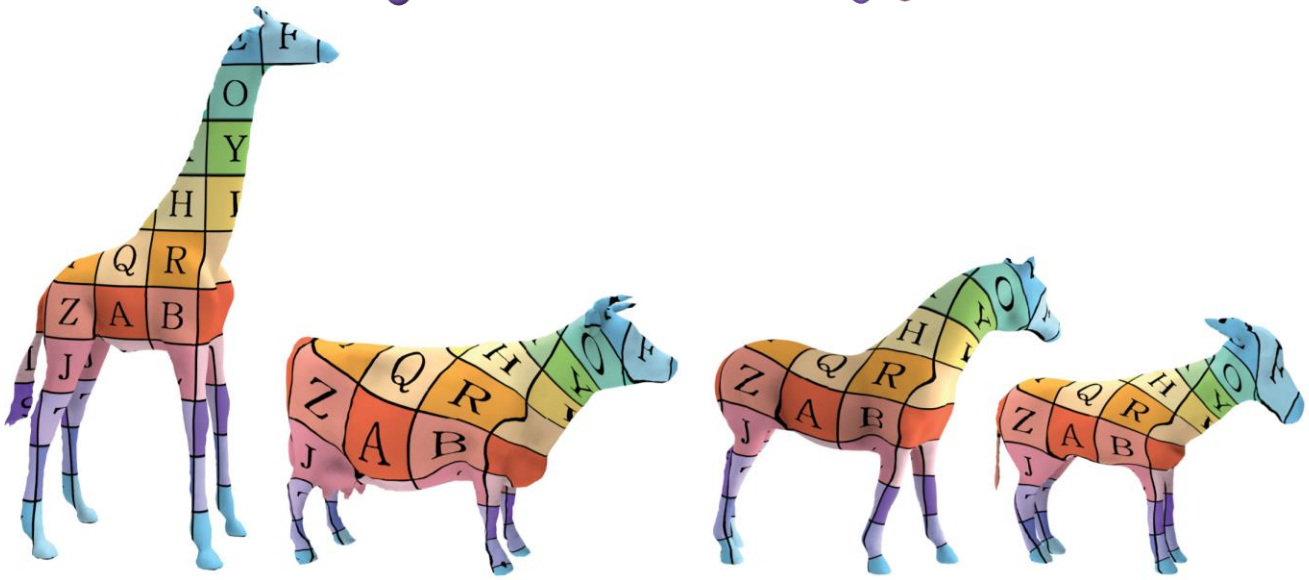
Output:

A correspondence



Technical challenge:

Very different geometries



"ENIGMA: Evolutionary Non-Isometric Geometry Matching", Michal Edelstein, Danielle Ezuz and Mirela Ben-Chen. ACM Transactions on Graphics, 39(4), SIGGRAPH 2020.
"Elastic Correspondence between Triangle Meshes", Danielle Ezuz, Behrend Heeren, Omri Azencot, Martin Rumpf and Mirela Ben-Chen. Computer Graphics Forum, 38(2), Eurographics 2019.

Research expertise

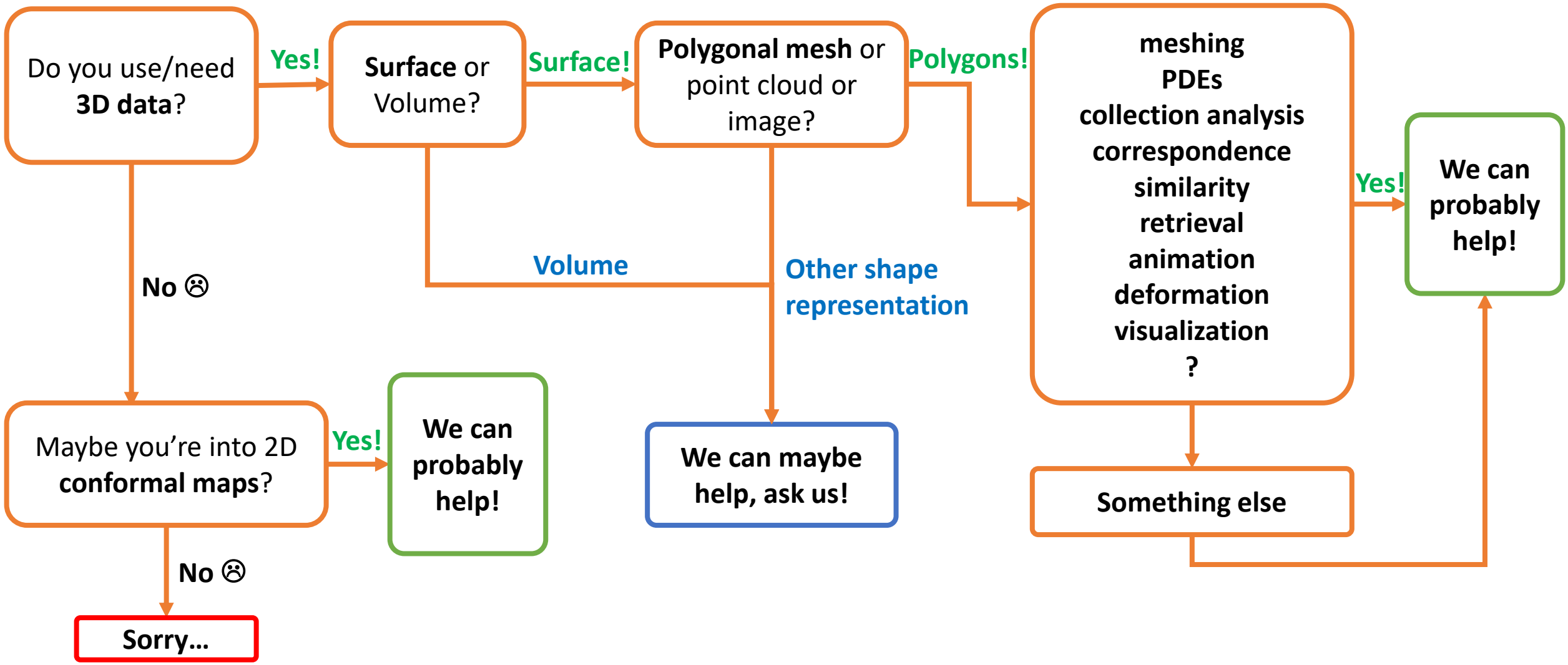
- 3D Geometry processing (mostly polygonal meshes)

- **Meshing**
  - "How can I decompose the shape to a **collection of elements with certain properties**"?
  - "How can I **fabricate** a given shape from a **given material**?"

- **Shape analysis**:
  - "Are these two shapes **the same**?"
  - "Which **points** on these two shapes **correspond**?"
  - "In **which regions** are these two shapes the same?"
  - "What can I learn from this **collection of similar shapes**?"
  - "What is the **closest shape** in the collection to this input shape?"

- **Solving PDEs** on surfaces (numerically)
  - "How can I compute gradient, divergence and other **differential operators** on discrete surfaces"?
  - "How can I guarantee **consistent** behavior under a flow"?
  - "How can I work with **velocities**, and other **non-scalar data** on discrete surfaces"?
  - "How can I solve PDEs **fast**?"

Can we help with your research problem?



Thank you!

Center for Graphics and Geometric Computing

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