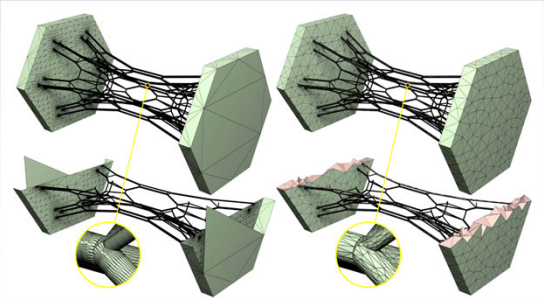
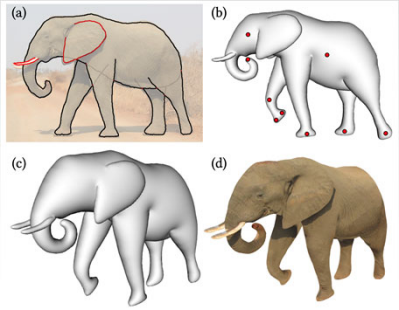
Advances in Geometry Processing (CPSC 533A)

https://www.cs.ubc.ca/~sheffa/cpsc533A/

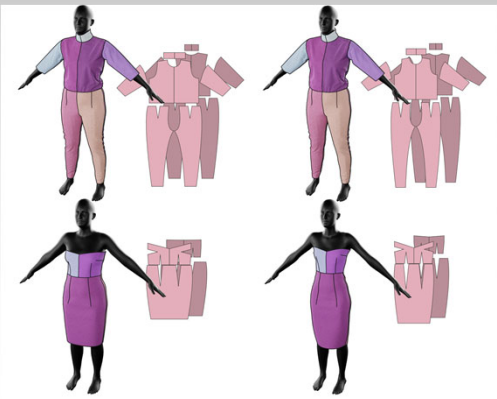
Alla Sheffer

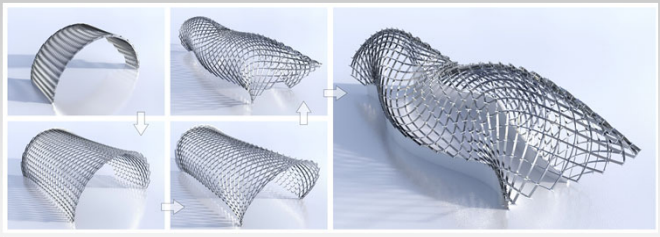


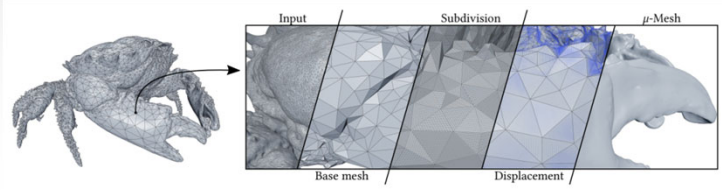


What is it about?

State of the Art Research on Creation & Manipulation of Shapes (geometry) (3D or 2D)

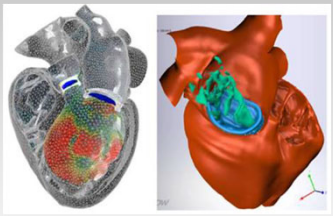




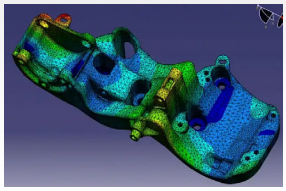


Why do we care about geometry (shape)?

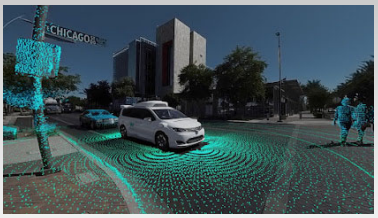
Shape is a primary characteristic of most objects around us (natural or human-made)



Medicine/Biology



Engineering/Simulation



Computer Vision& Robotics

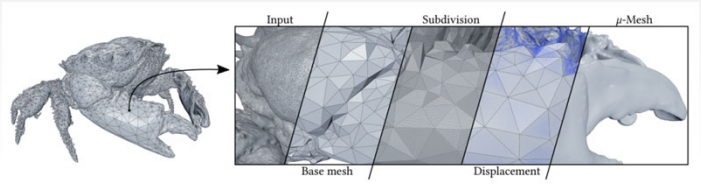
Games/Movies/VR

Fabrication

Course Focus

Getting Familiar with State of the Art Geometry Creation & Processing Algorithms

- Reading/Discussing recent work
- Hands-on experience with implementing an example method



Course Format & Processes

Course Info

Instructor (me): Alla Sheffer

- Office: ICICS/CS x651
- e-mail: sheffa@cs.ubc.ca
- Office hours (virtual unless requested otherwise) by appointment

TA: Suzuran Takikawa

- *Office hours by appointment*

Web page: https://www.cs.ubc.ca/~sheffa/cpsc533A

- Includes all course material
- Piazza page: https://piazza.com/ubc.ca/winterterm12026/cpsc533a
  - *Link from course page*
  - *Info on all changes & news*
  - ***Please check OFTEN***

Format

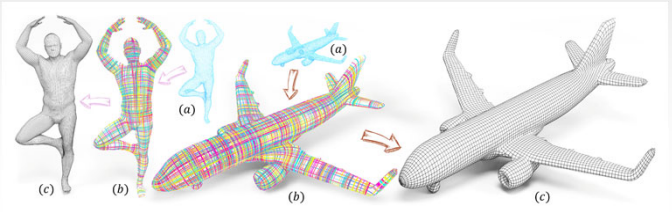
Seminar-style lectures + hands-on project

Seminar-style lectures

- One recent paper per class
- Role-playing discussion format

Hands-on projects

- Topic selected early in the term
- Periodic progress updates in class
- Final presentation



Seminar Lectures

Seminar structure

- One recent paper per class
- Role-playing discussion format with 4 presenter roles
- Each role presenter gives a ~10 minute presentation.
- Class discussion follows. **Everyone should read the paper in advance.**
- Students will submit anonymous feedback for presenters on Piazza (private post). This should include a brief summary and constructive feedback.

Seminar Lectures

Presenter Roles

- Historian
  - *Deep dive into relevant prior work*
- Presenter
  - *Present paper: key ideas & algorithms*
- Positive Reviewer
  - *Describe and emphasize key contributions of the work*
  - *Discuss positive impact since publication (when applicable)*
- Critical Reviewer
  - *Provide a critical review of the work & its limitations*
  - *Discuss limitations observed since publication (when applicable)*

Hands-on Project

Project Formats

- Option 1:
  - *Implement a paper from the course (if code not available) or refine/extend a paper.*
- Option 2:
  - *Incorporate advanced geometry processing methods into your own research.*
- Project group size: ~2 people

Grading

45%: Paper Presentations

- 16-18 papers – each student presents ~4-5 papers
- Each student is expected to play each role roughly same number of times
- Grade depends (partly) on feedback from other students
- ***Bonus for early presentations***: first presentation (8%), second (5%), third (3%)

45%: Final Project

- Project proposal – 5%
- Mid-term check-in 1 – 8%
- Mid-term check-in 2 – 8%
- Completed project – 24%

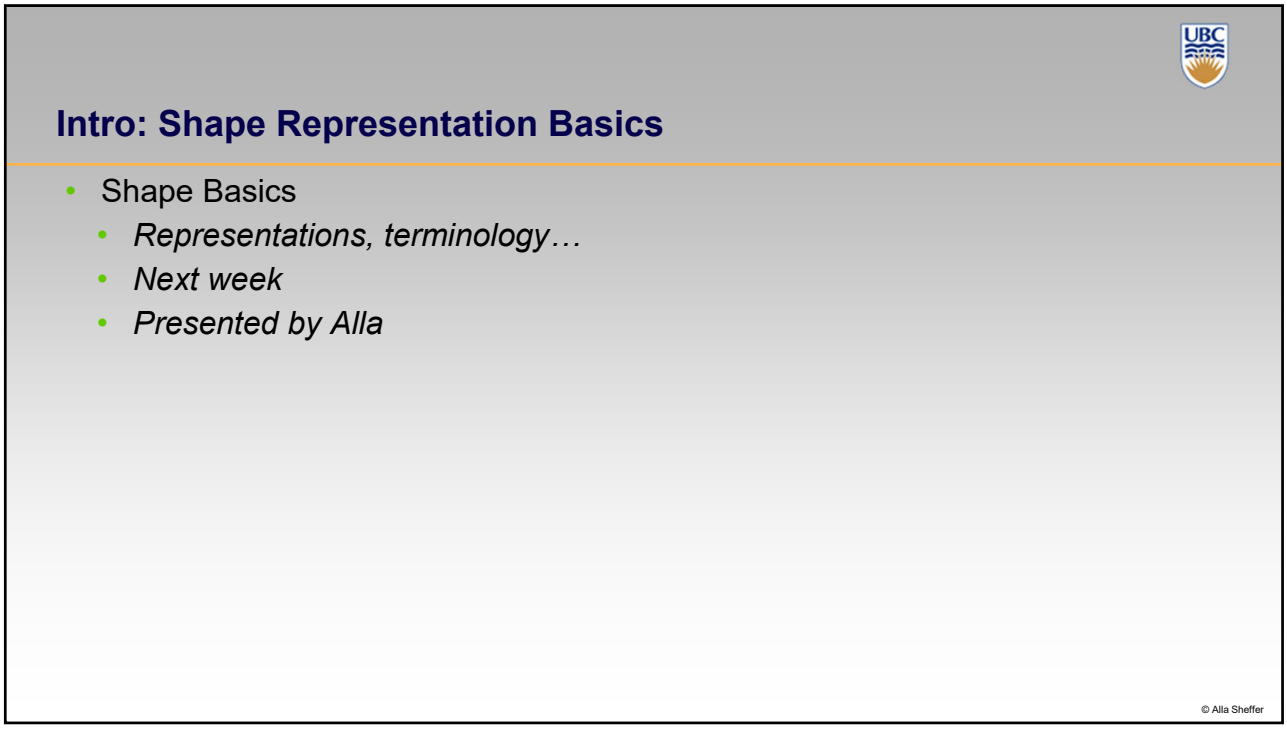
10%: Participation

- Paper presentation feedback (Piazza) + general classroom discussion participation

Tentative Schedule

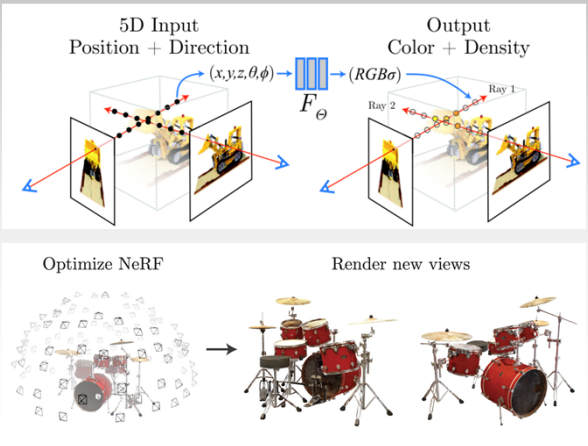
Week 1 (Sep 10)	Introduction
Week 2 (Sep 15 & 17)	Geometry Basics/Paper discussion (?)
Week 3(Sep 22 & 24)	Paper discussions
Week 4 (Sep 21 & Oct 1)	Paper discussions
Week 5 (Oct 6 & 8)	**Project proposals (Oct 6)** / Paper discussion (Oct 8)
Week 6 (Oct 13 & 15)	Paper discussions
Week 7 (Oct 20 & 22)	Paper discussions
Week 8 (Oct 27 & 29)	**Project mid-term check-in I (Oct 27)** /Paper discussion (Oct 29)
Week 9 (Nov 3 & 5)	Paper discussions
Week 10 (Nov 12)	Paper discussion
Week 11 (Nov 17 & 19)	**Project mid-term check-in II (Nov 17)** /Paper discussion (Nov 19)
Week 12 (Nov 24 & 26)	Paper discussions
Week 13 (Dec 1 & 3)	Paper discussion/Summary
Week TBD	**Final project presentations (later in December)**


Course Topics
(Tentative List, will not cover everything)
© Alla Sheffer


Intro: Shape Representation Basics
Shape Basics
Representations, terminology…
Next week
Presented by Alla
© Alla Sheffer

Shape Reconstruction

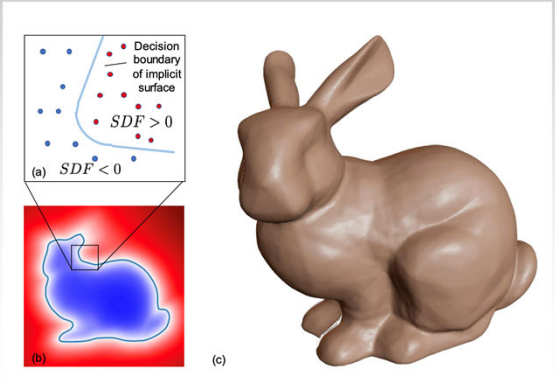
- NeRF: Representing Scenes as Neural Radiance Fields for View Synthesis
- 3D Gaussian Splatting for Real-Time Radiance Field Rendering

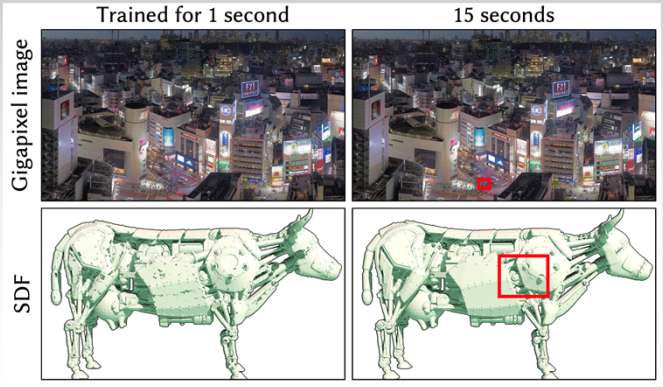


Final Rendering 3D Gaussian Visualization

Neural Shape Representation

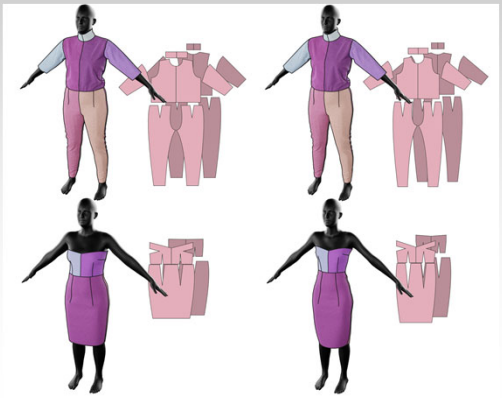
- DeepSDF: Learning Continuous Signed Distance Functions for Shape Representation
- Instant Neural Graphics Primitives with a Multiresolution Hash Encoding





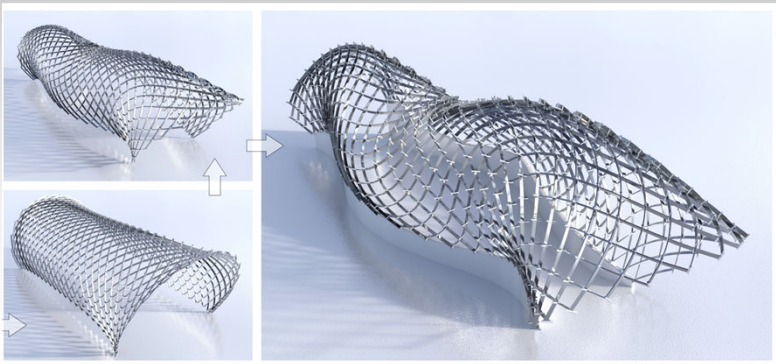
Garment Modeling

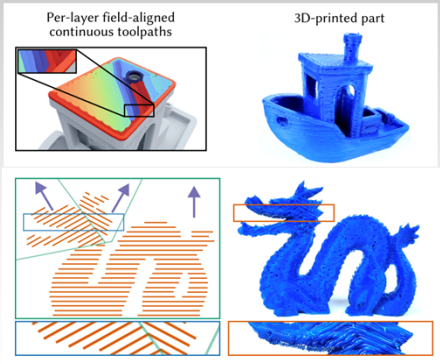
- GarmentCode: Programming Parametric Sewing Patterns
- Intersection-Free Garment Retargeting



Fabrication

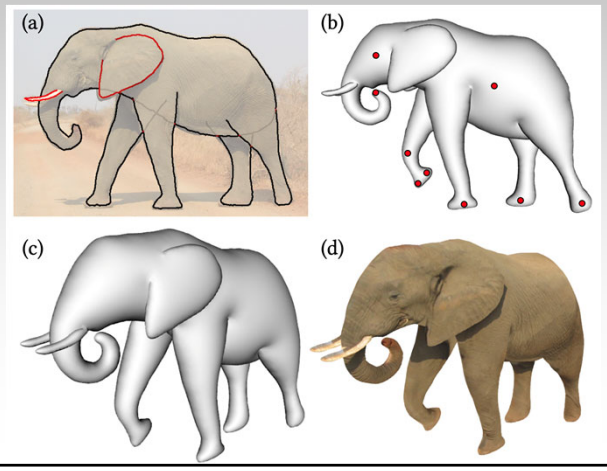
- Deployable strip structures
- AtomSlicer: Constant-Thickness Field-Aligned Non-Planar Slicing andContinuous Toolpaths for FF

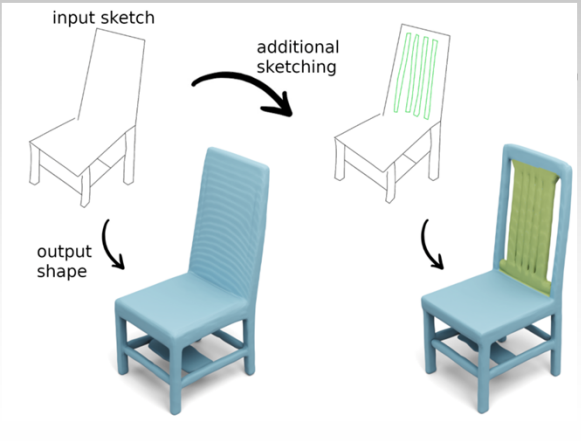




Sketch-based Modeling

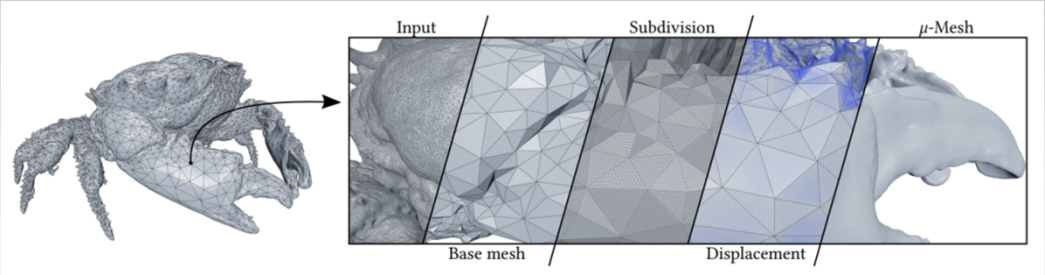
- Monster Mash: A Single-View Approach to Casual 3D Modeling and Animation
- SENS: Part-Aware Sketch-based Implicit Neural Shape Modeling

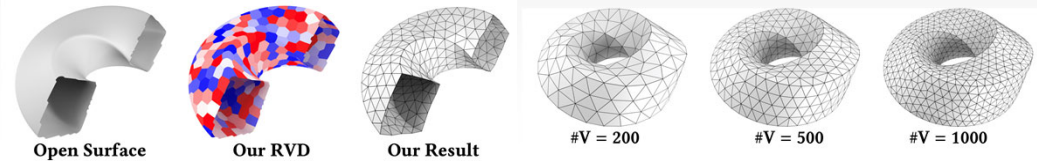




Simplification / Remeshing

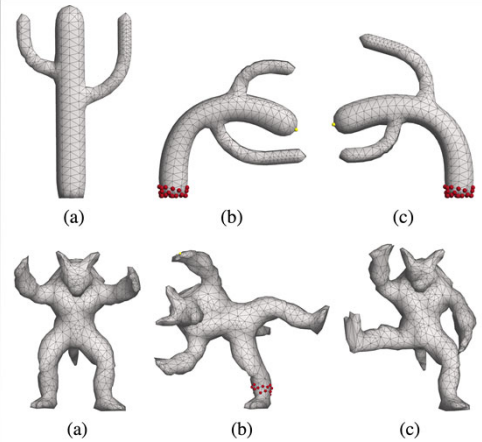
- Micro-Mesh Construction
- CWF: Consolidating Weak Features in High Quality Mesh Simplification





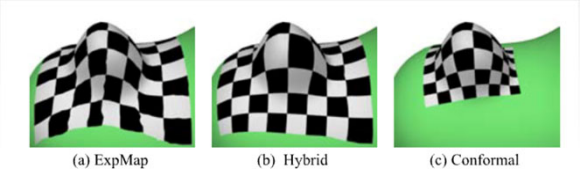
Deformation

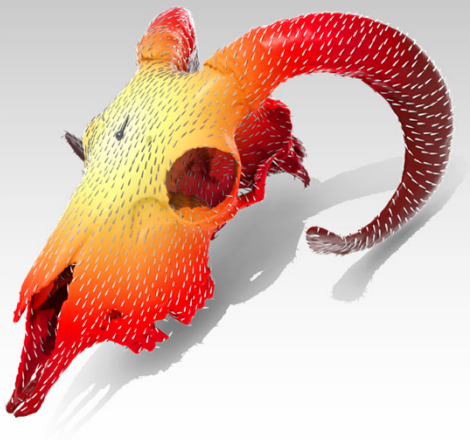
- As-rigid-as-possible surface modeling
- Character articulation through profile curves



Differential Geometry

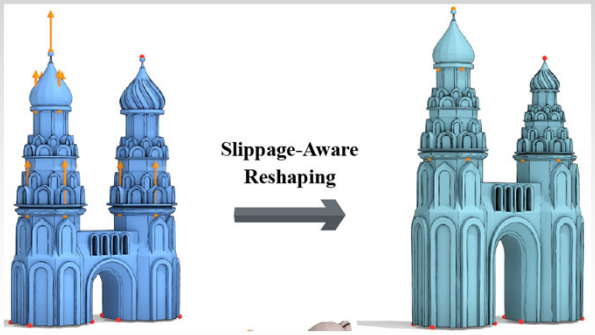
- Interactive decal compositing with discrete exponential maps
- The Vector Heat Method





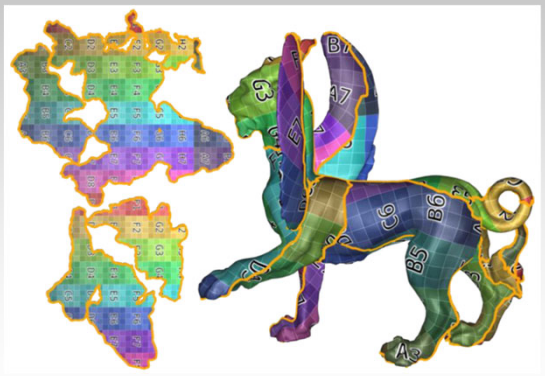
Perceptual Shape Processing

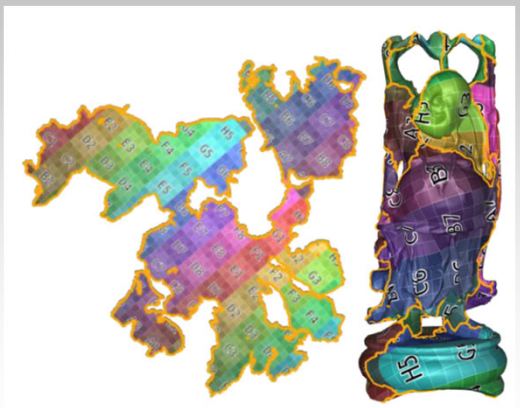
- As-Locally-Uniform-As-Possible Reshaping of Vector Clip-Art
- Variational Neural Surfacing of 3D Sketches
- Slippage-Preserving Reshaping of Human-Made 3D Content



Parameterization

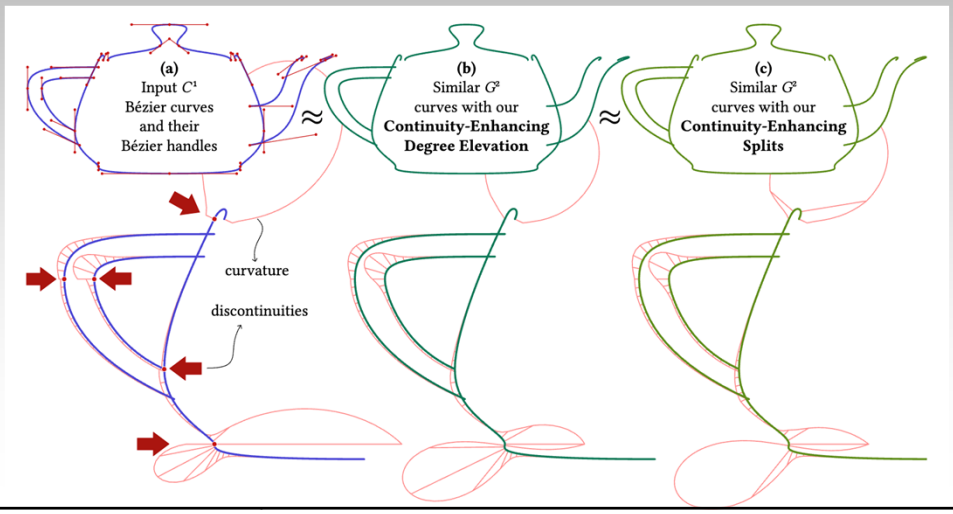
- OptCuts: joint optimization of surface cuts and parameterization





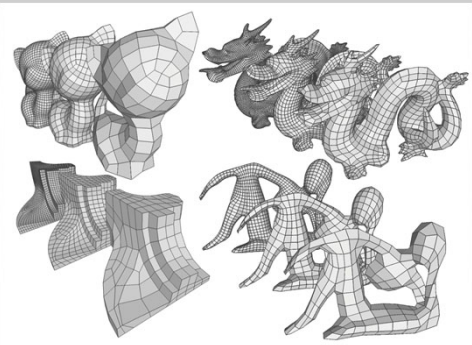
Curves

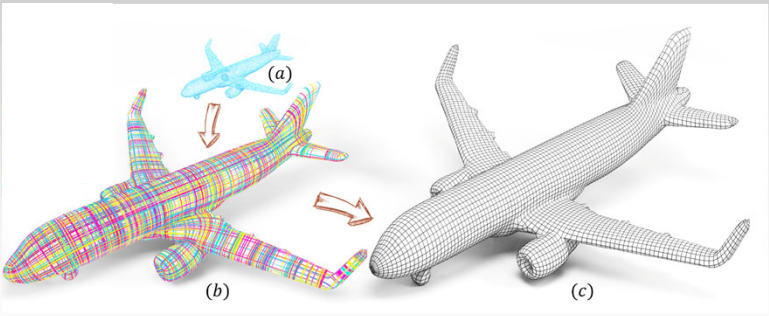
- Continuity-Enhancing Degree Elevation and Splits



Quadrangulation

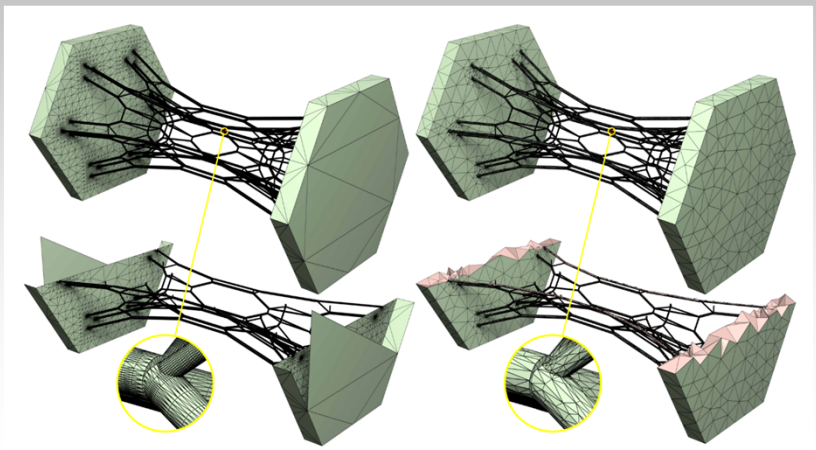
- Reliable Feature-Line Driven Quad-Remeshing
- CrossGen: Learning and Generating Cross Fields for Quad Meshing





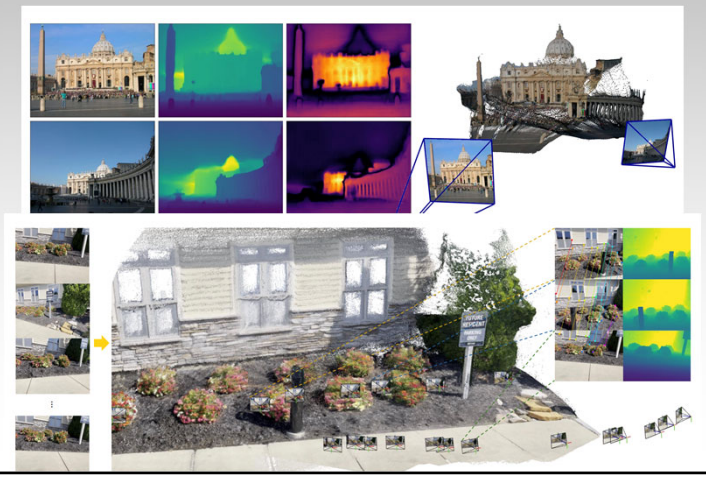
Volume Meshing

- Fast tetrahedral meshing in the wild



3D Vision

- DUSt3R: Geometric 3D Vision Made Easy
- VGGT: Visual Geometry Grounded Transformer



Winding Numbers

- The Antipodal Method: Fast, Accurate, and Robust 3D Generalized Winding Numbers