Introduction to Digital Geometry Processing

USTC, 2024 Spring

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https://qingfang1208.github.io/

What is (Digital) Geometry Processing?

Geometry Processing from wikipedia

> Geometry processing is an area of research that uses concepts from applied mathematics, computer science and engineering to design efficient algorithms for the acquisition, reconstruction, analysis, manipulation, simulation and transmission of complex 3D models.

3D Graphics

Real 3D object
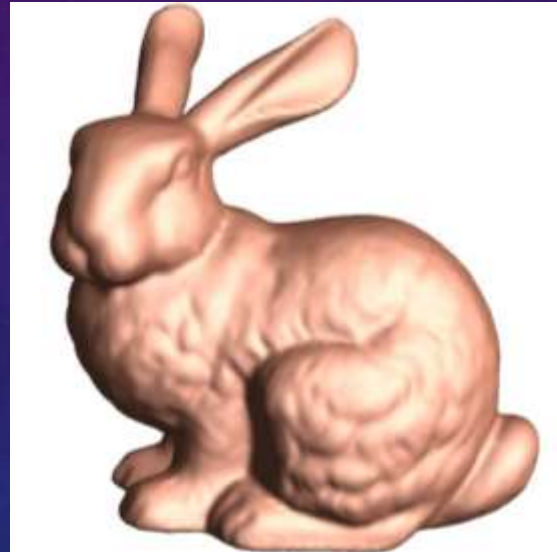
Digital representation

- Rendering
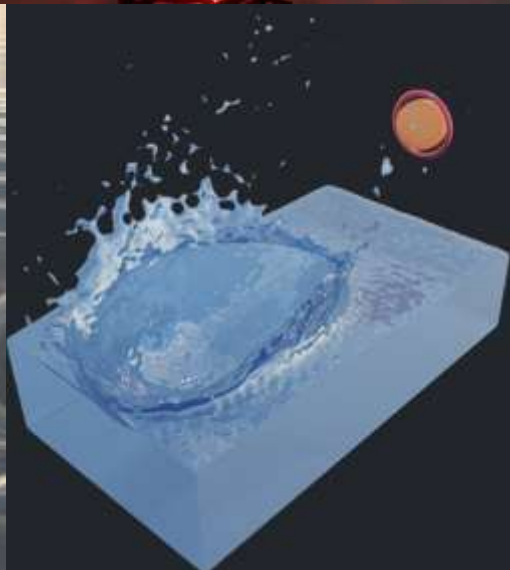- Animation
- Interaction
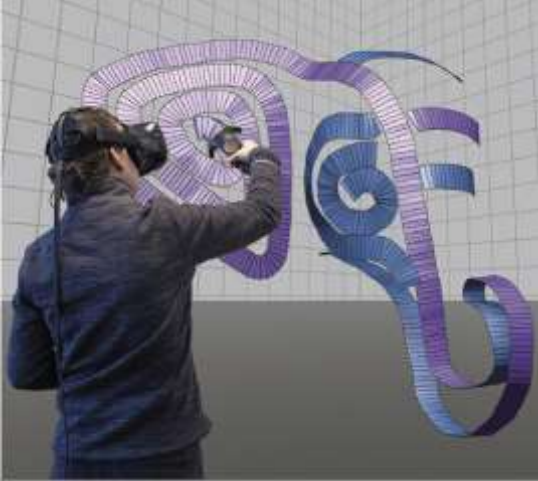- ...

Rendering

- Geometry
- Material
- Illumination

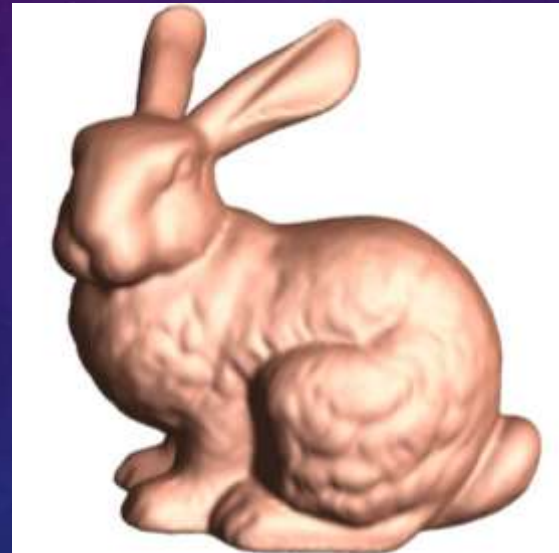# Animation

Animation

Interaction

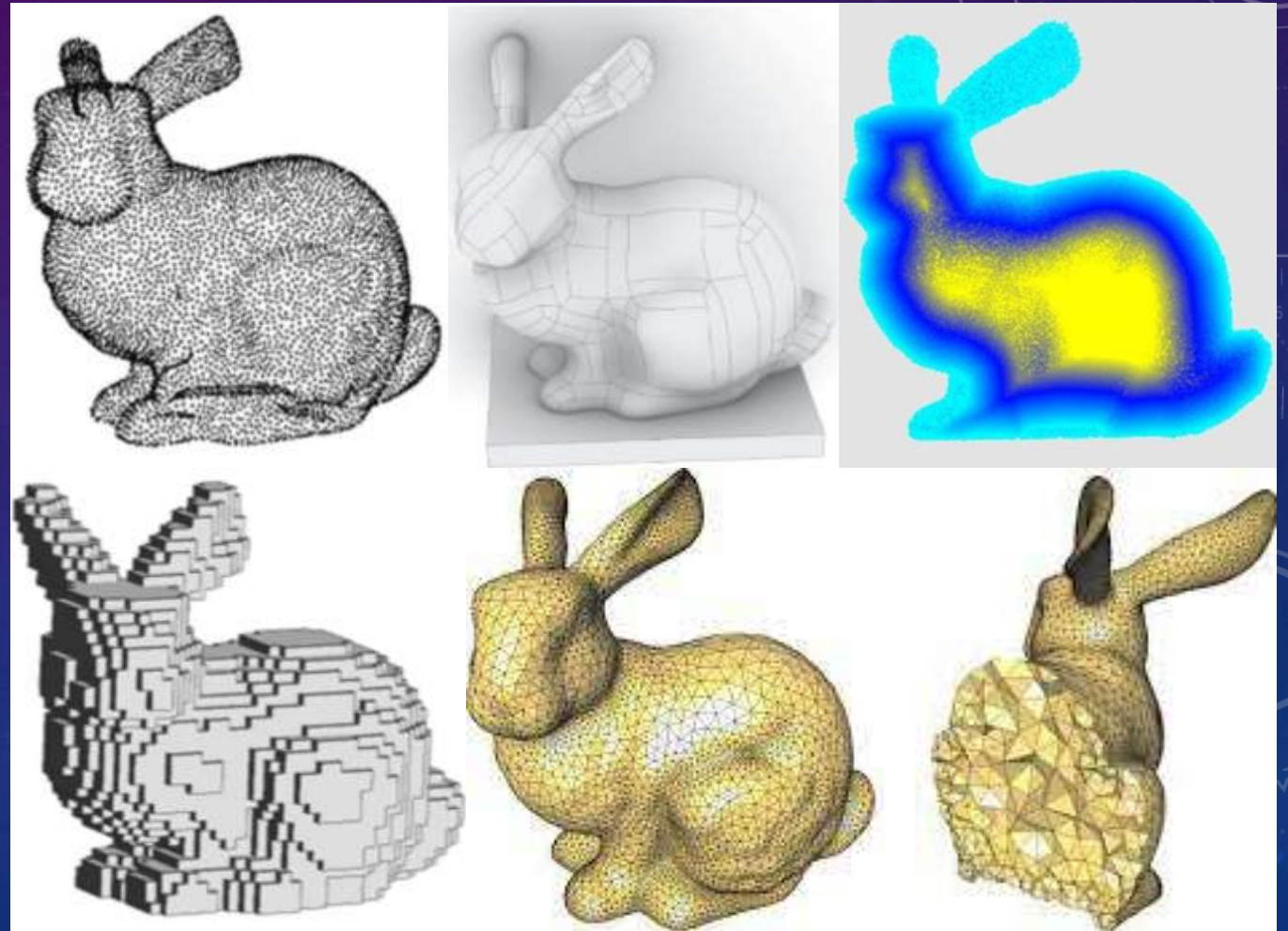# 3D Graphics

Real 3D object

Digital representation

- Rendering
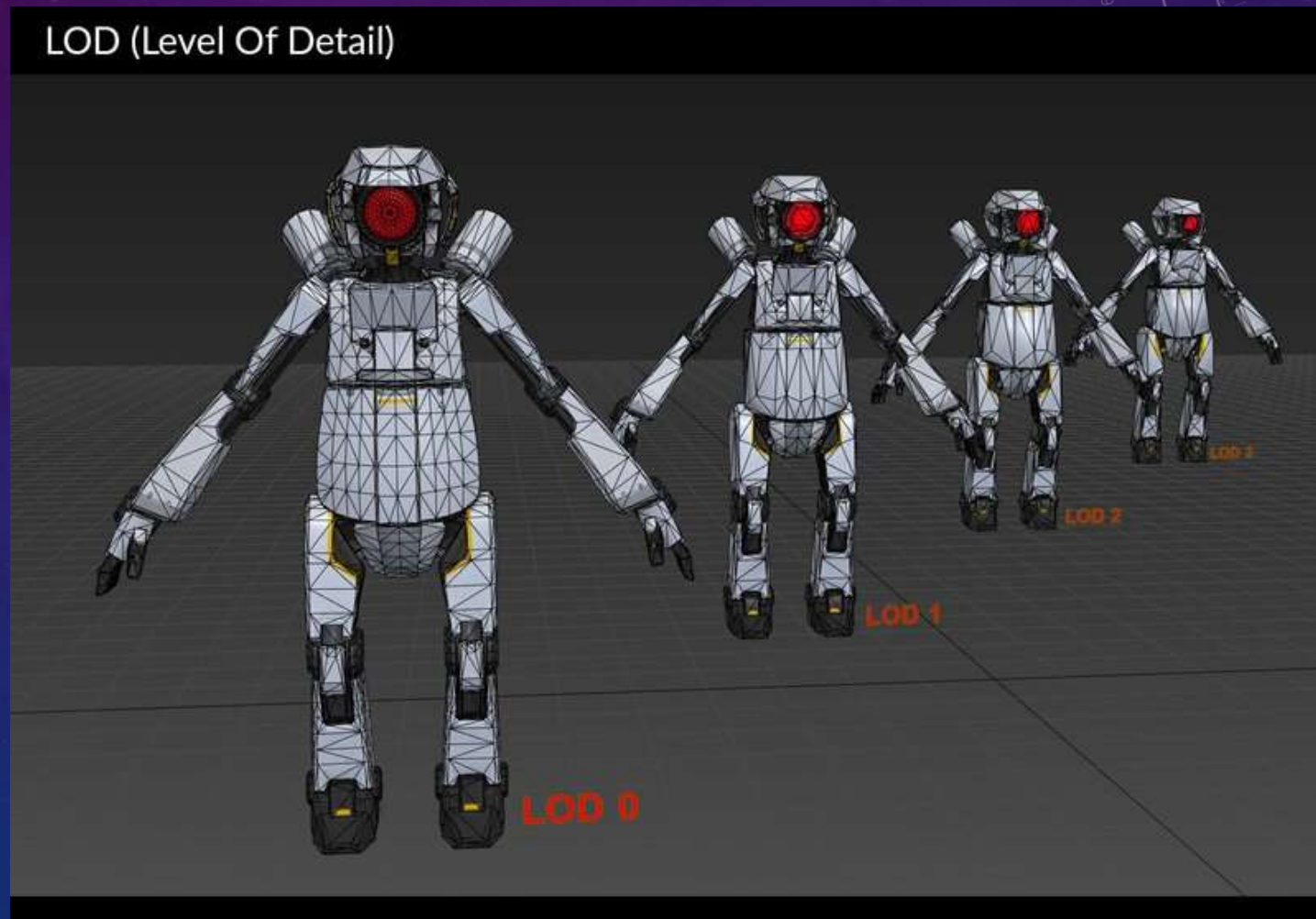- Animation
- Interaction
- …

Digital representation

- Point cloud

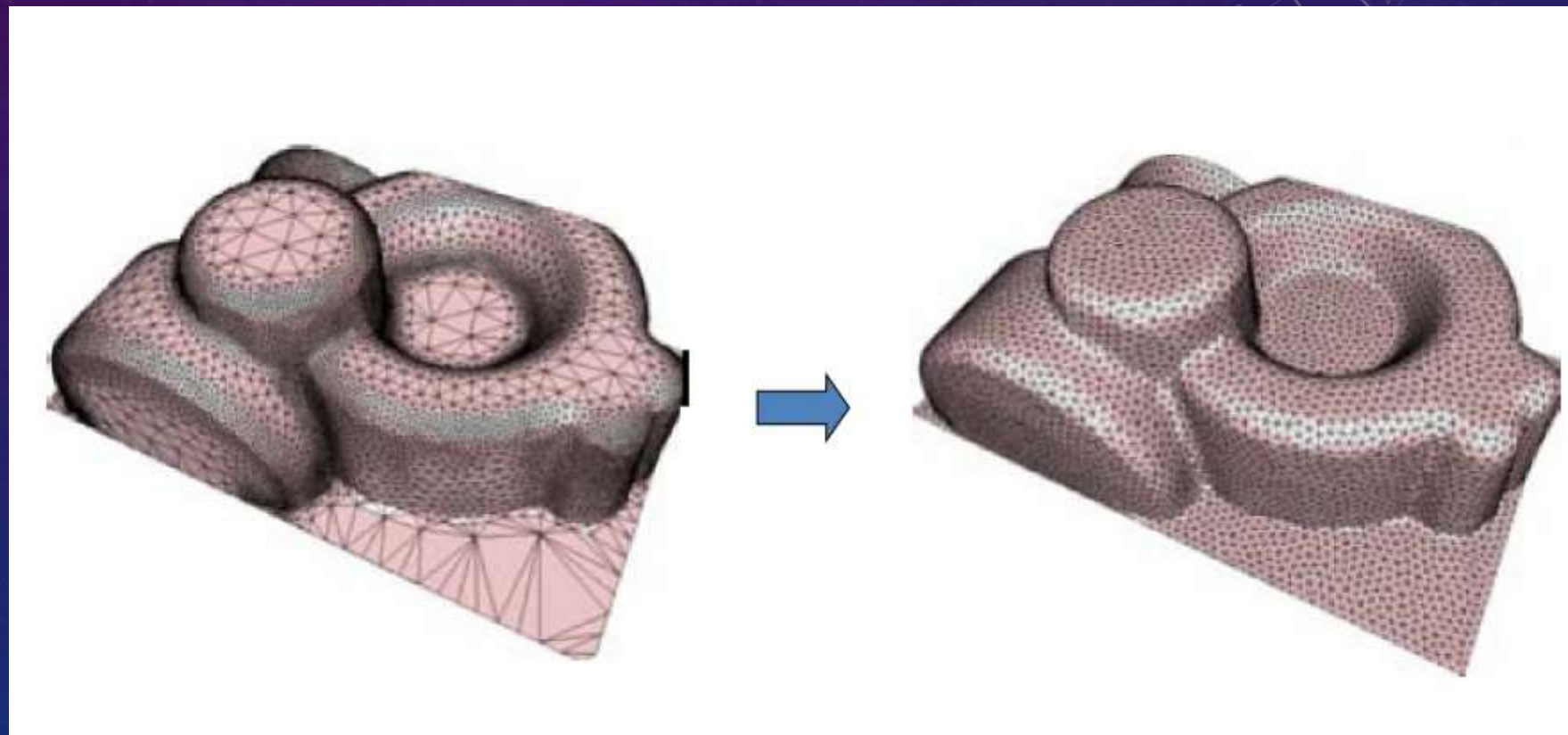- Explicit/implicit function

- Grid

- Triangular/tetrahedral Mesh
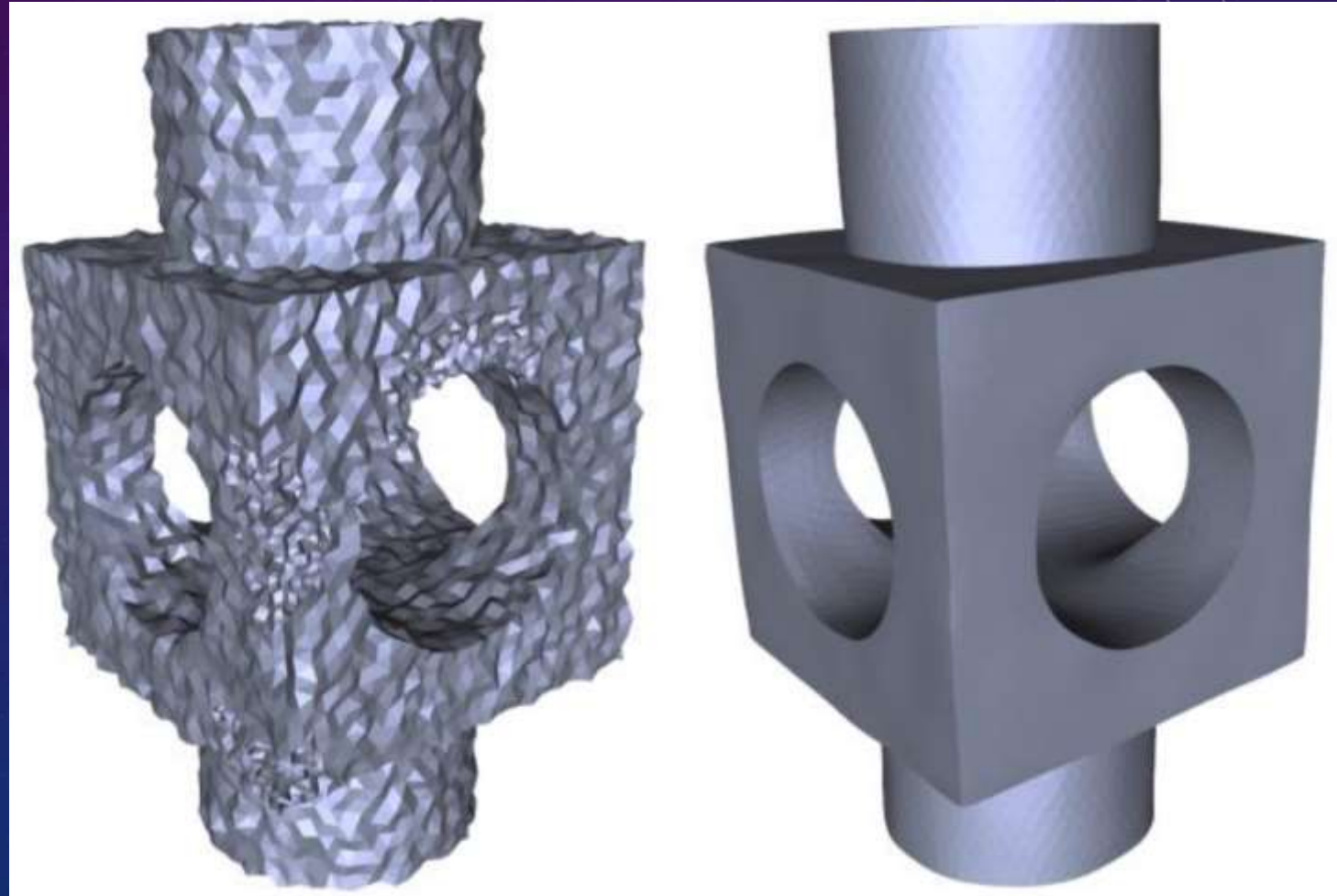
- …

Applications

➢ **Simplification**

Applications

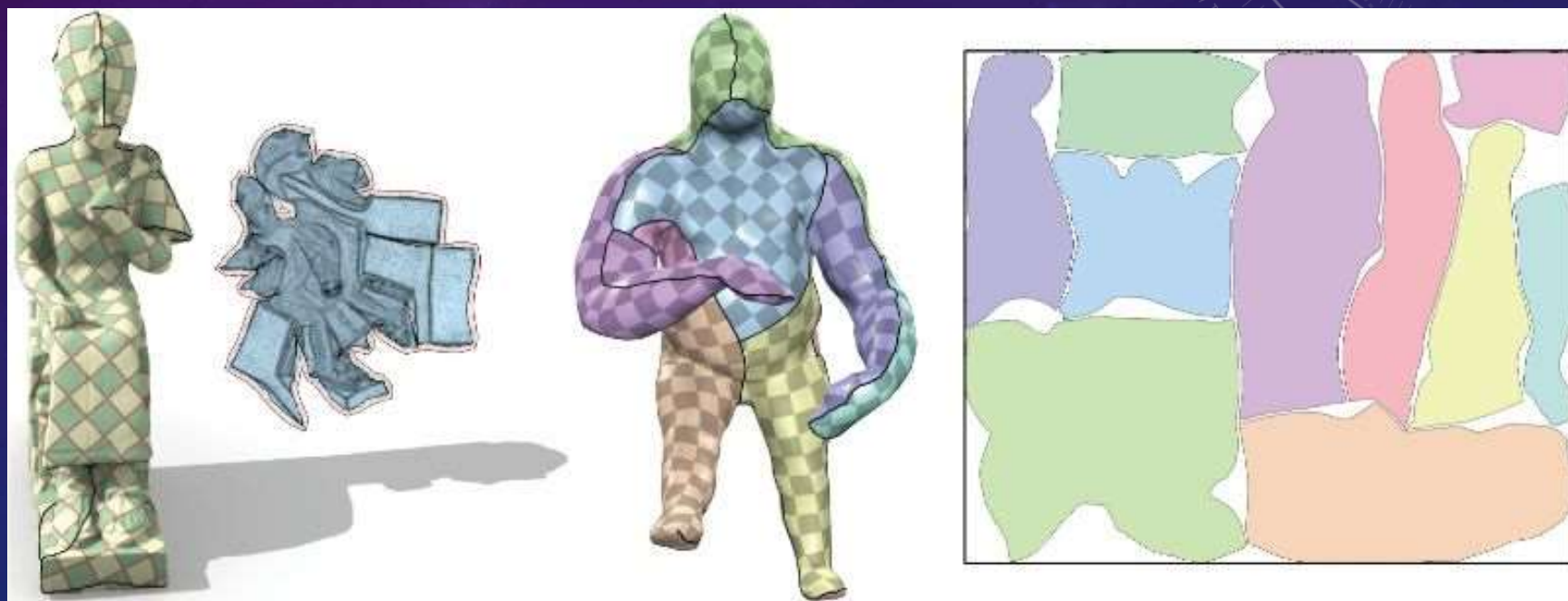- Simplification

- Remeshing

Applications

- Simplification
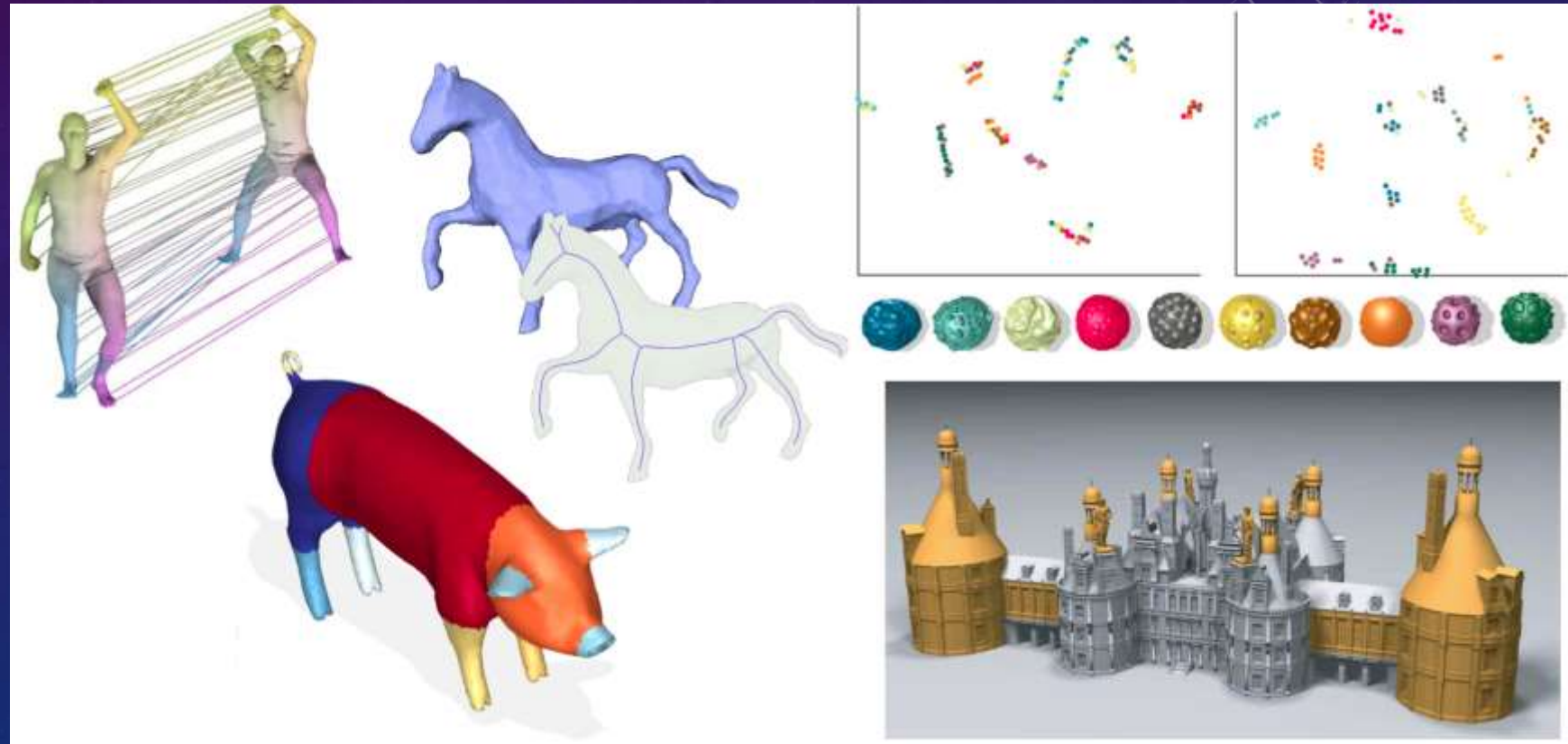
- Remeshing

- Smoothing

Applications

- ➢ Simplification
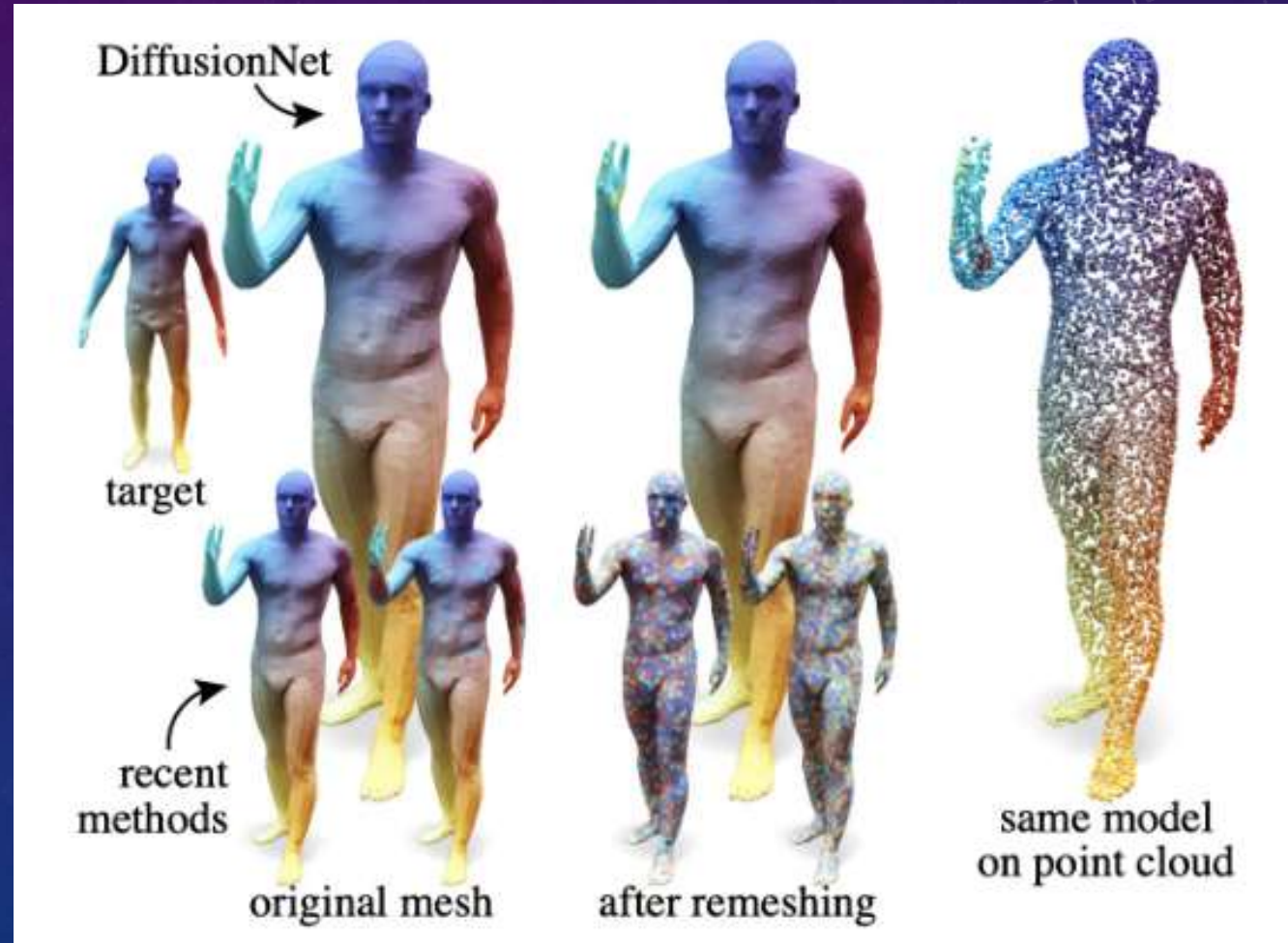- ➢ Remeshing
- ➢ Smoothing
- ➢ Parameterization

Applications

- Simplification

- Remeshing

- Smoothing

- Parameterization
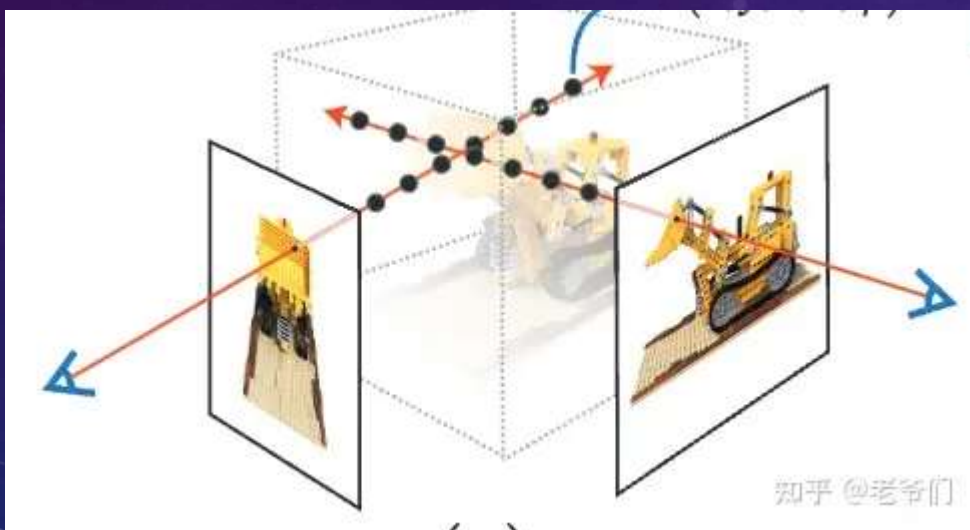
- Shape analysis

- …

Applications

- Simplification
- Remeshing
- Smoothing
- Parameterization
- Shape analysis
- Geometry learning
- ...

Frontiers

➢ Reconstruction

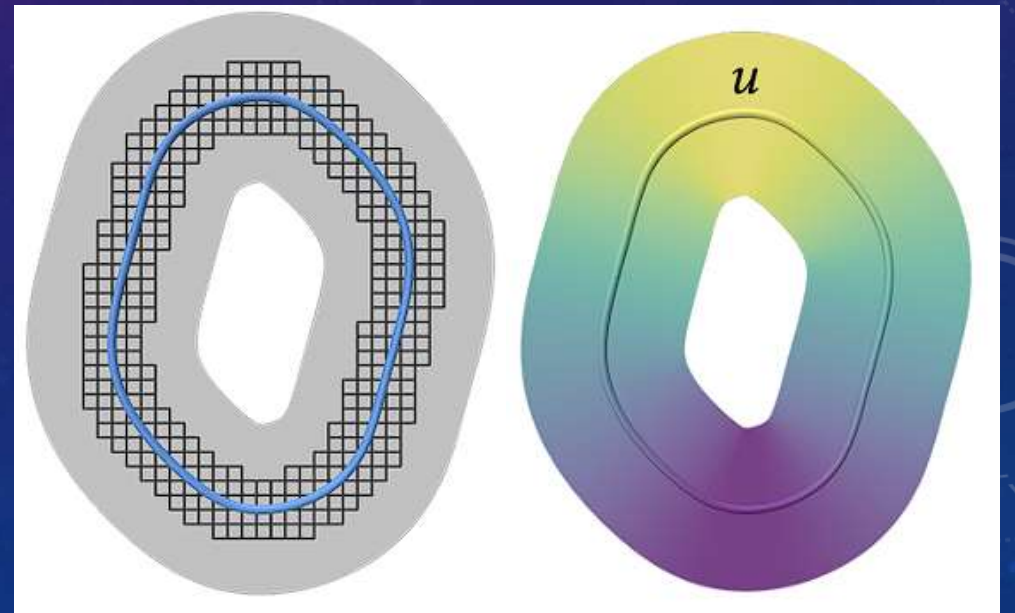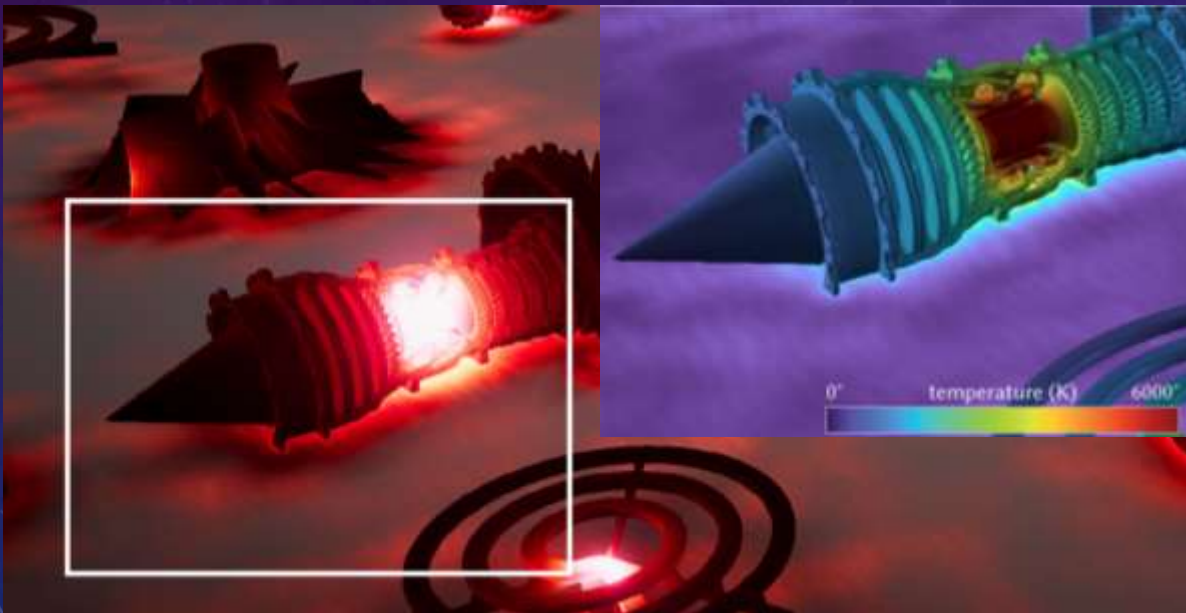- Volume rendering：NERF -> 3D Gaussian splatting

Frontiers

➢ Diffusion model

- Sketch modeling, shape completion, layout generation …

Frontiers

- PDE with no meshing

  - Monto Carlo, closest point method

Future Trend

➢ Sora

What will we learn?

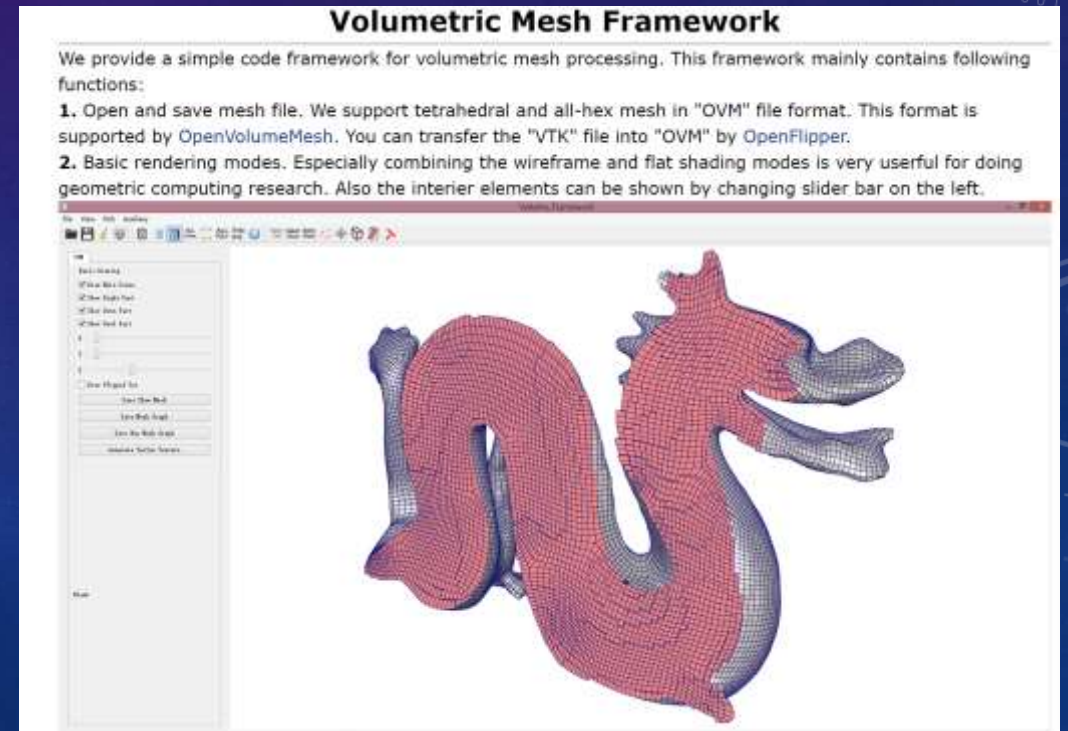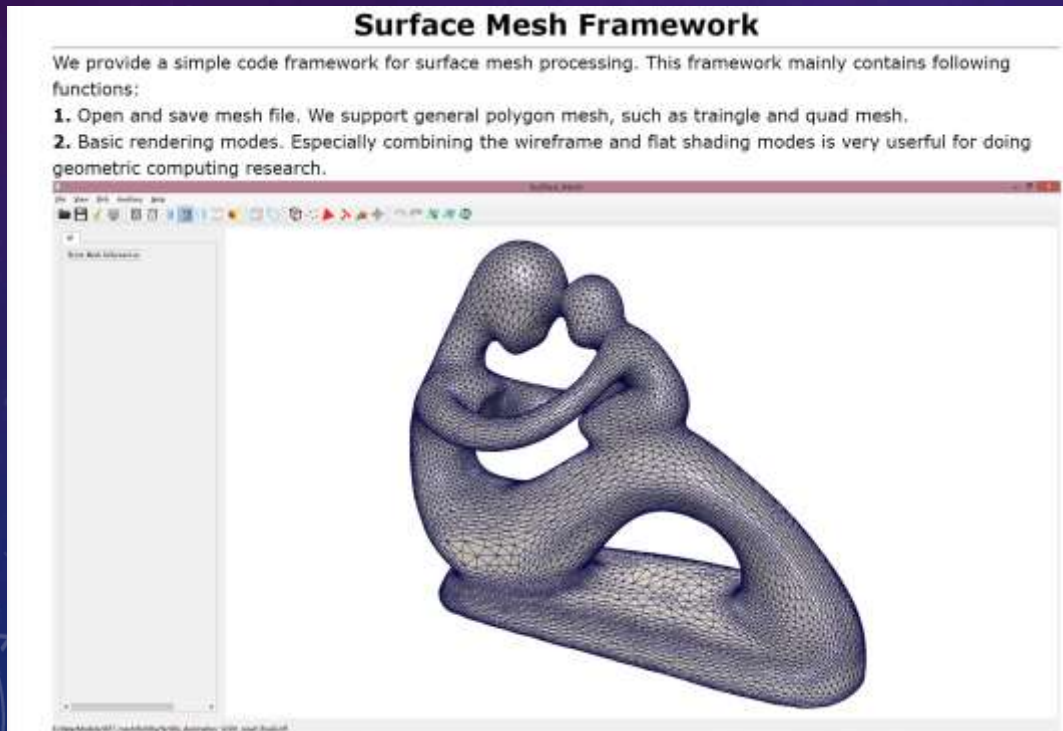# About this course

- ➢ Goal

  - Digital representation (data structure) and differentials (from smooth to discrete)

  - Basic coding for applications (simplification, smoothing, deformation, …)

  - Academic frontiers

- ➢ Score

  - ➢ Coding ($5 \times 10 = 50$) + exam (20)

  - ➢ Survey + presentation (30)

Prerequisites

➢ Math: calculus, linear algebra, differential geometry, PDE …

➢ Coding: C++ (https://ustc-gcl-f.github.io/code/index.html#sec_surface_framework)

Surface Mesh Framework

We provide a simple code framework for surface mesh processing. This framework mainly contains following functions:
1. Open and save mesh file. We support general polygon mesh, such as traingle and quad mesh.
2. Basic rendering modes. Especially combining the wireframe and flat shading modes is very userful for doing geometric computing research.

Volumetric Mesh Framework

We provide a simple code framework for volumetric mesh processing. This framework mainly contains following functions:
1. Open and save mesh file. We support tetrahedral and all-hex mesh in "OVM" file format. This format is supported by OpenVolumeMesh. You can transfer the "VTK" file into "OVM" by OpenFlipper.
2. Basic rendering modes. Especially combining the wireframe and flat shading modes is very userful for doing geometric computing research. Also the interier elements can be shown by changing slider bar on the left.

References

➤ Book: Polygon mesh processing

➤ Papers: https://www.kesen.realtimerendering.com/

➤ Other resources:

  • Siggraph courses

  • GAMES webinar

  • …
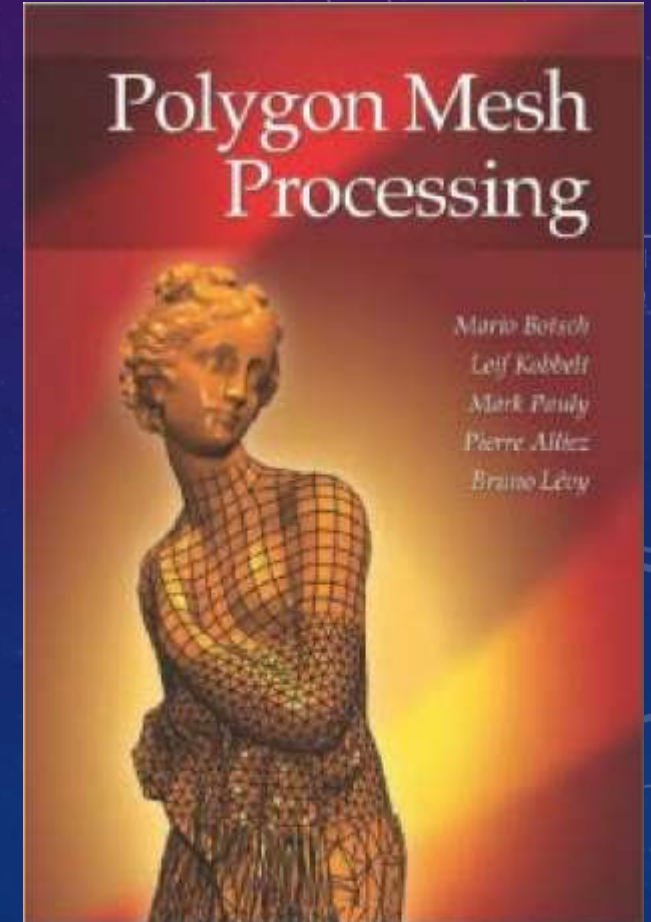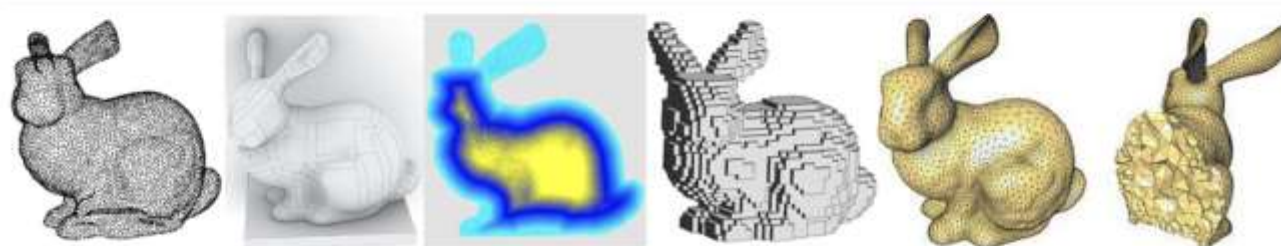
Course info

- Webpage: https://qingfang1208.github.io/Course/2024_spring_DGP/index.html

- QQ group: 852534294

Q&A