



Digital Geometry -Introduction

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Spring 2018

<http://jjcao.github.io/DigitalGeometry/>

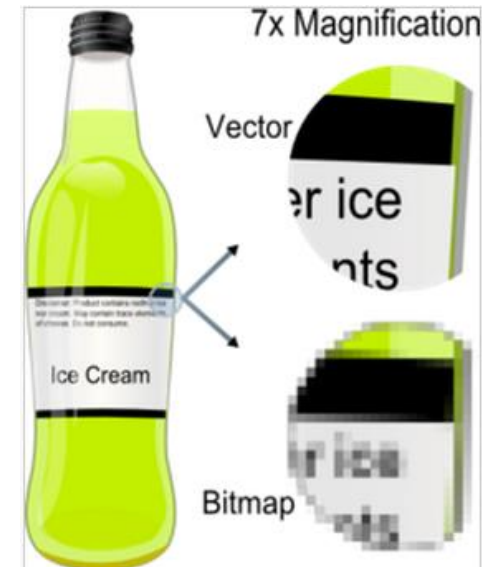
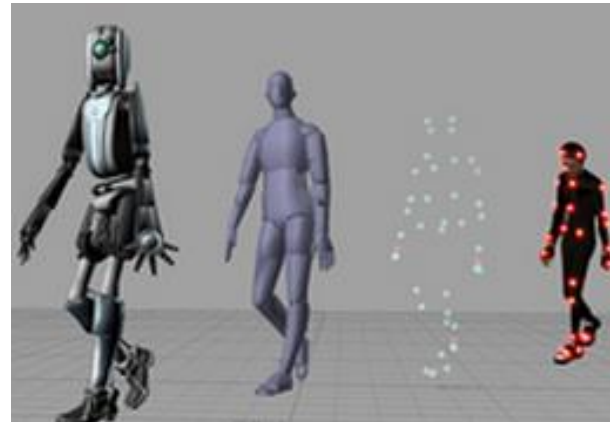
Pleasure may come from illusion, but happiness can come only of reality.

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What is CG?

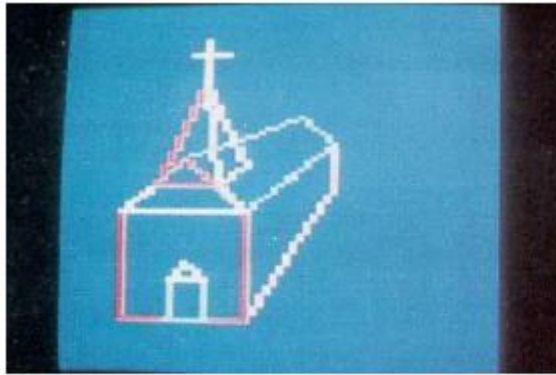
- The [study of computer graphics](#) is a sub-field of [computer science](#) which studies methods for **digitally synthesizing and manipulating visual content**.
 - 3D
 - Image processing
- CG studies the manipulation of **visual & geometric** information using *mathematical & computational* techniques.
- CG vs. [Visualization](#)



Computer Graphics

The big picture

- 3D graphics programming in 1979



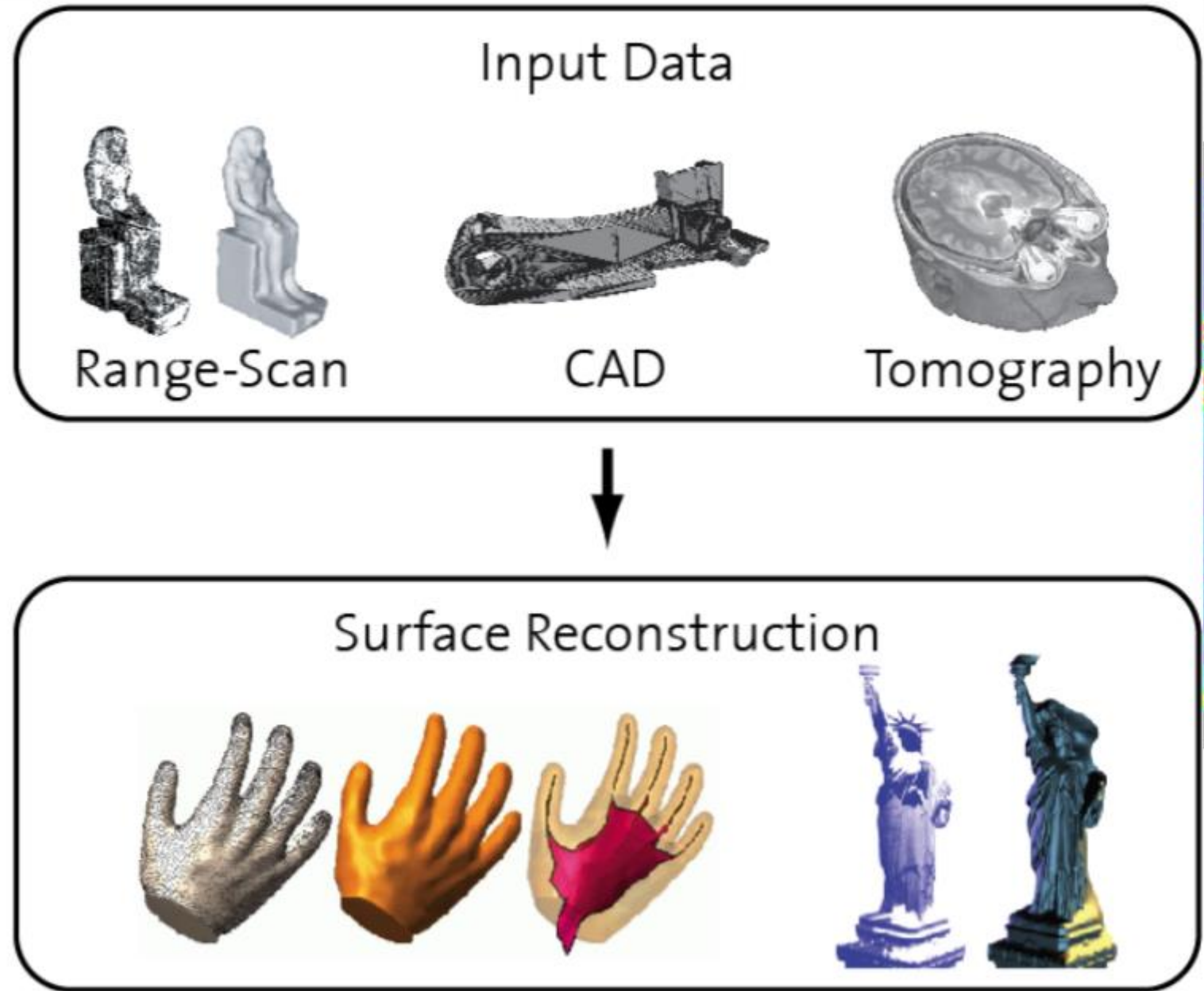
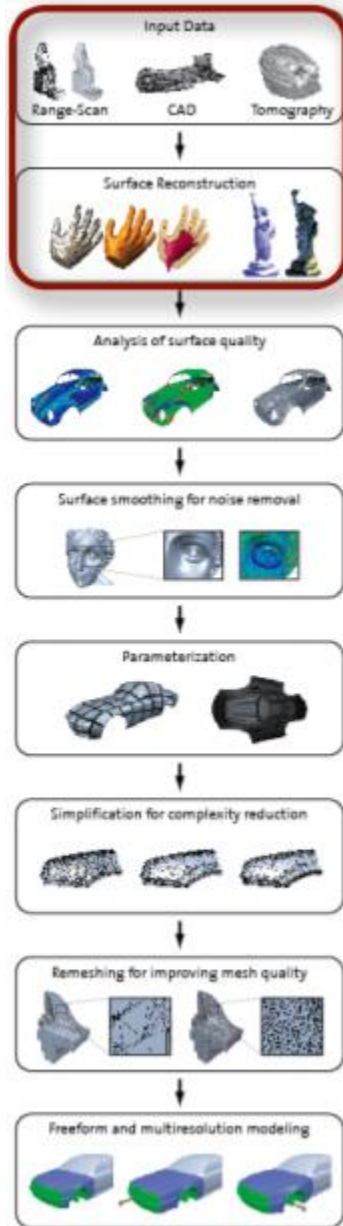
approx. 25 triangles



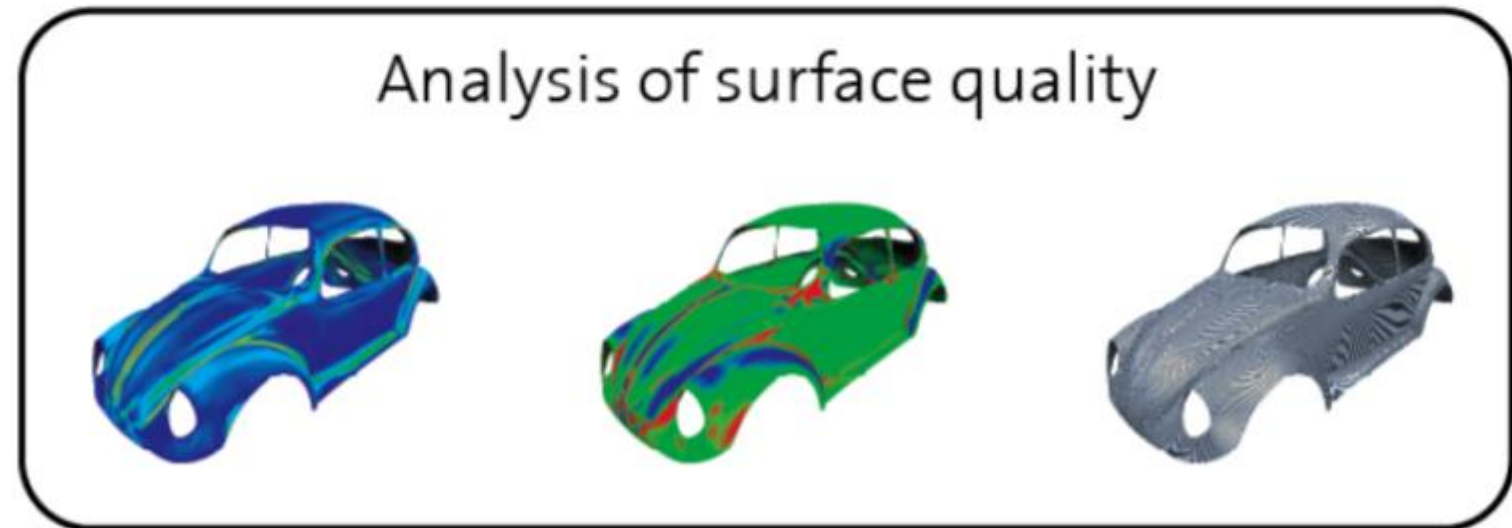
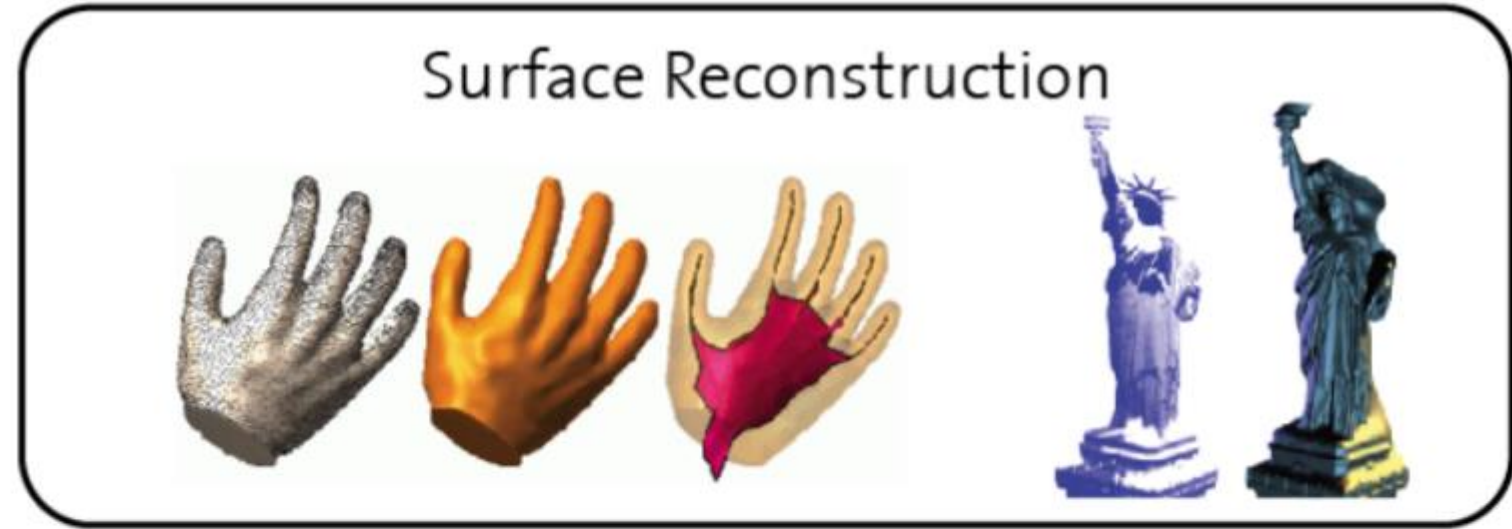
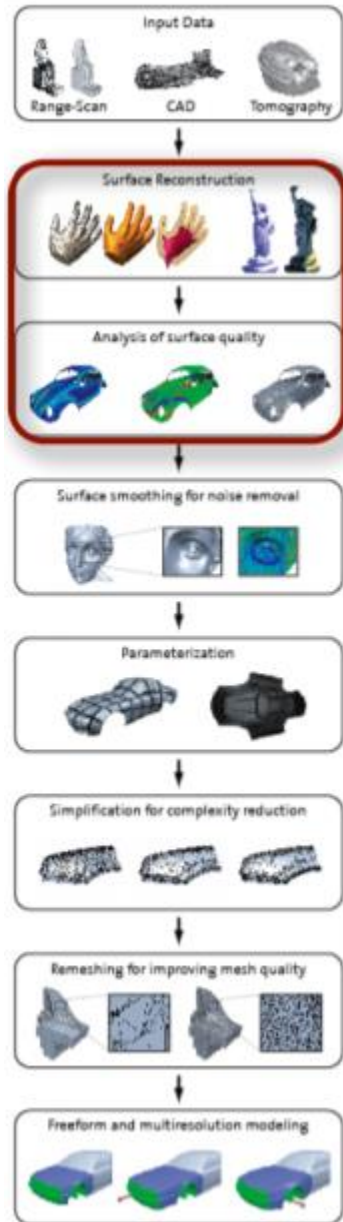
approx. 50 x 100 pixels



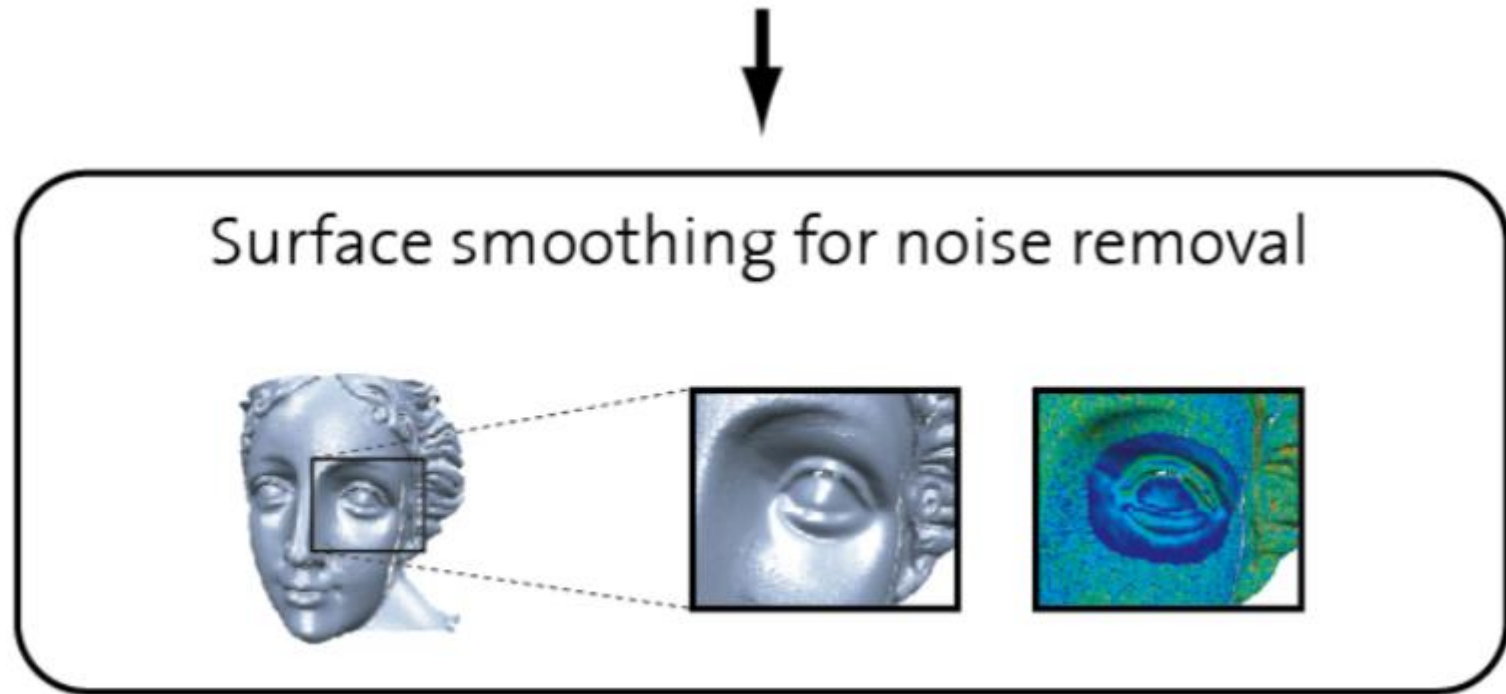
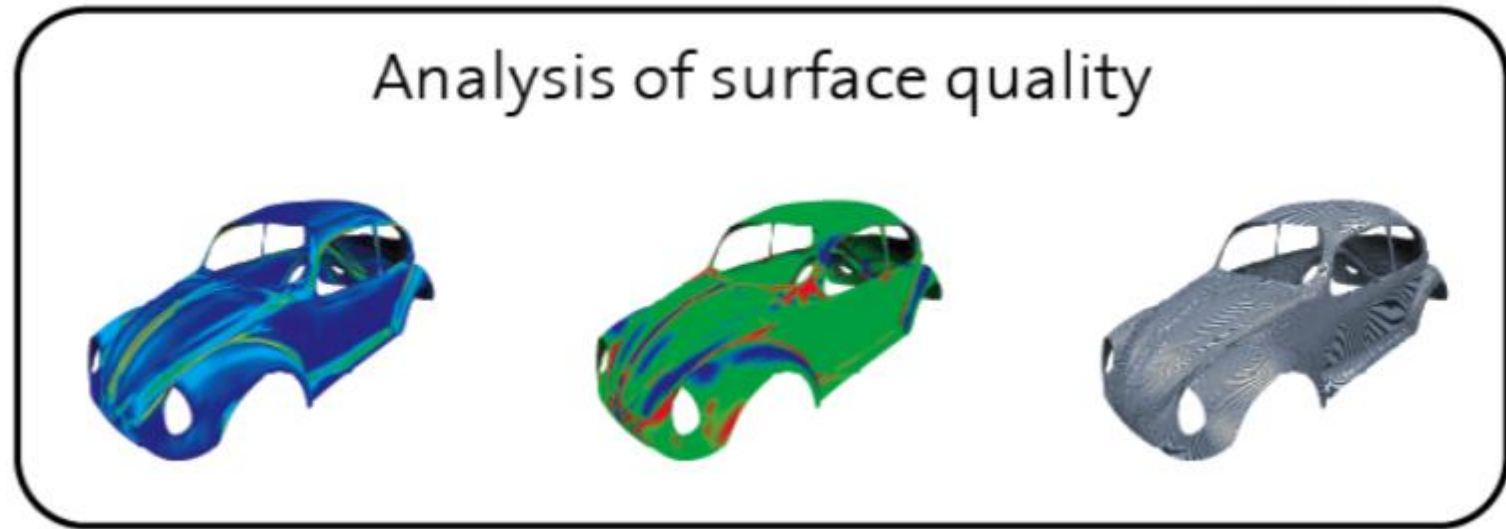
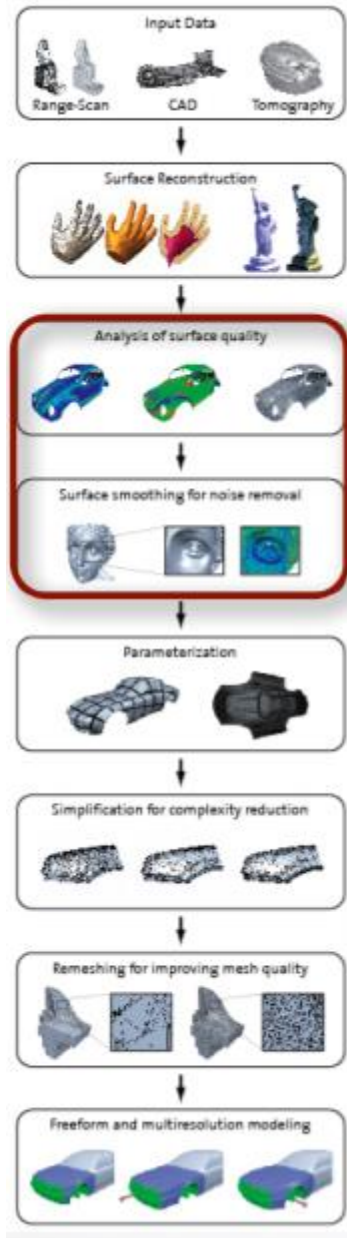
Geometry Processing Pipeline



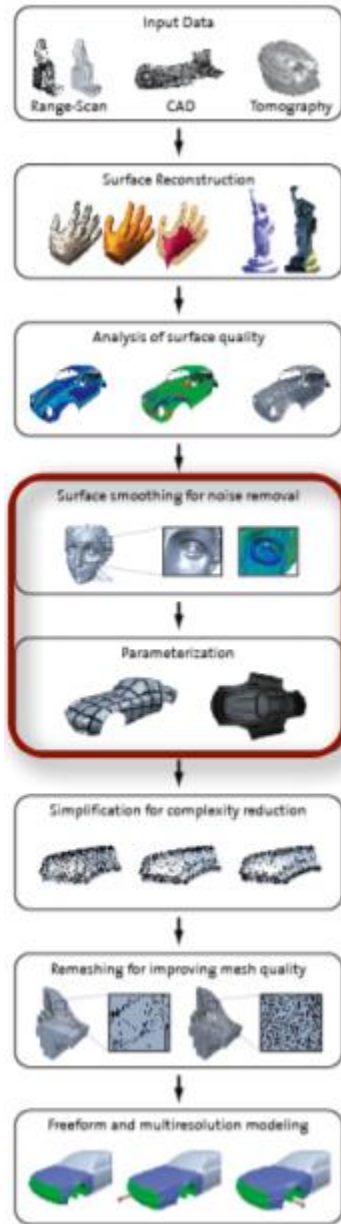
Geometry Processing Pipeline



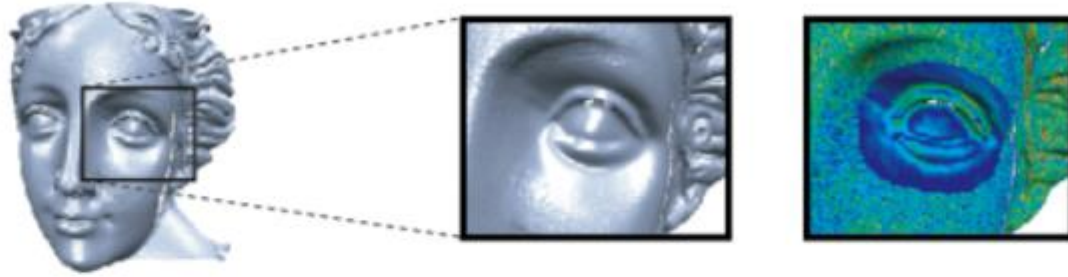
Geometry Processing Pipeline



Geometry Processing Pipeline



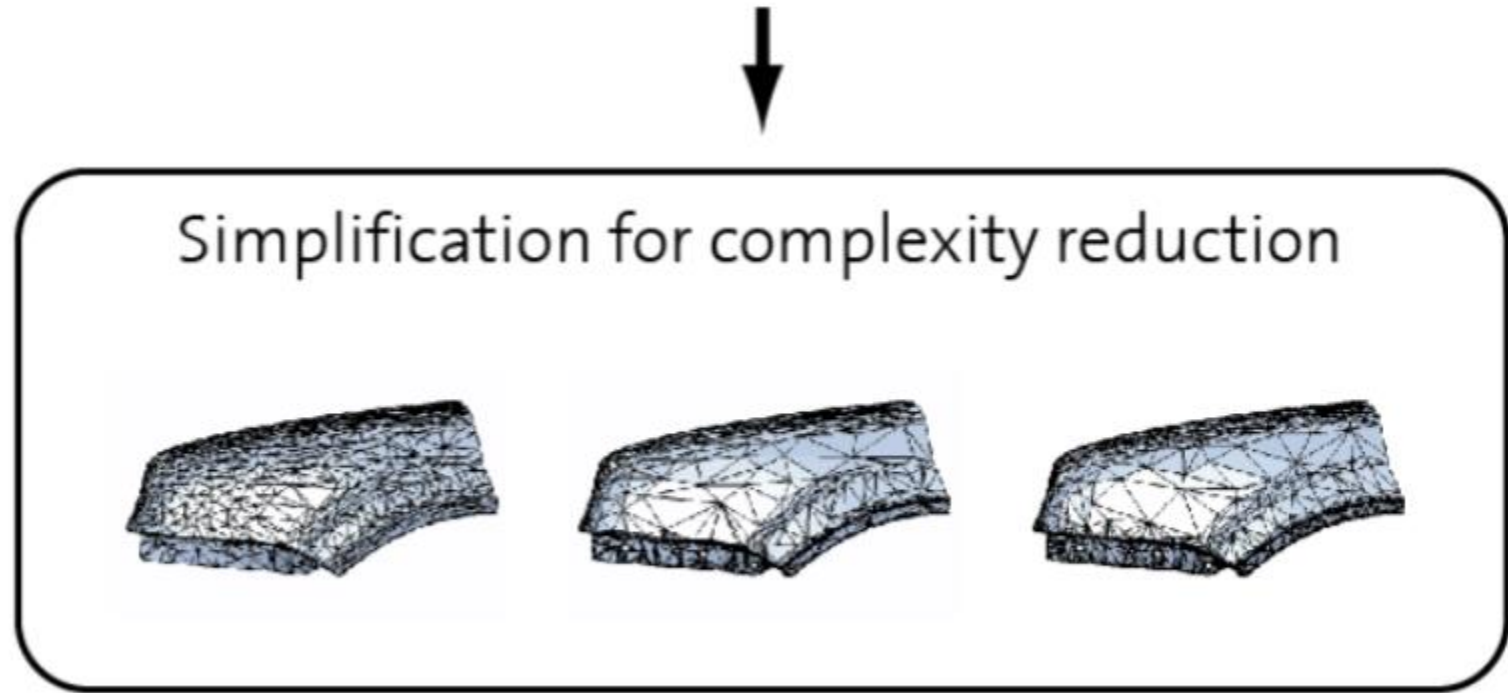
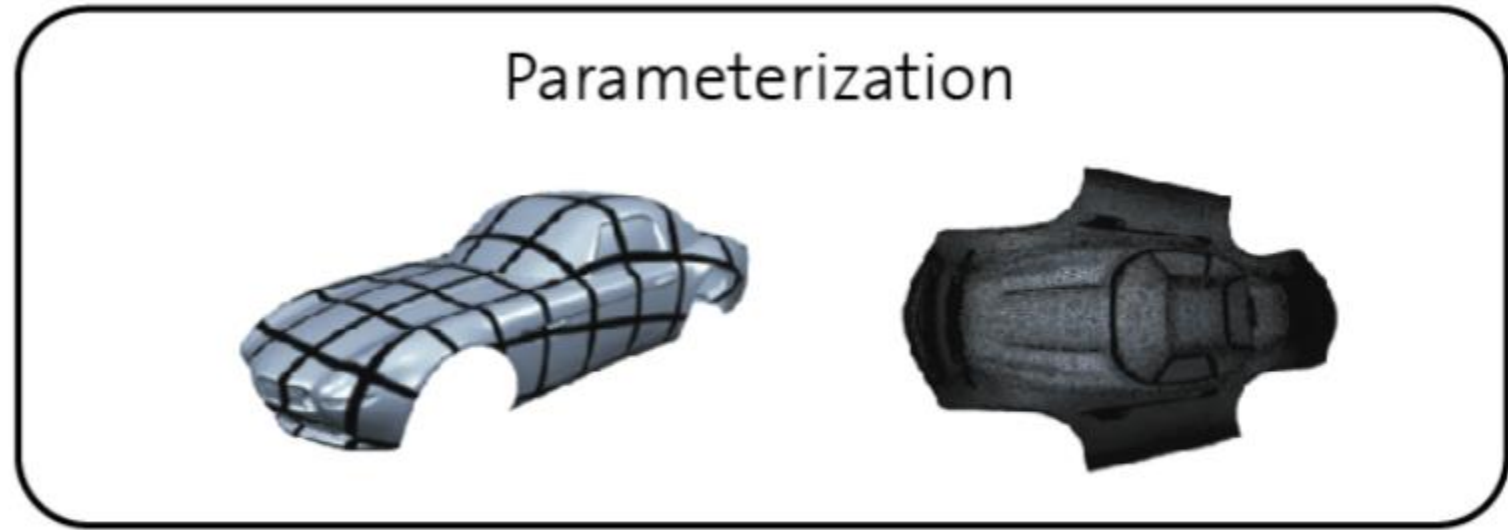
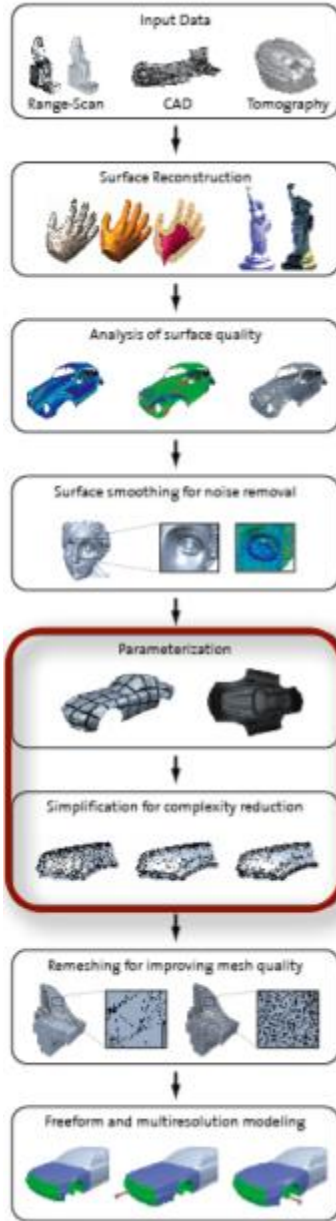
Surface smoothing for noise removal



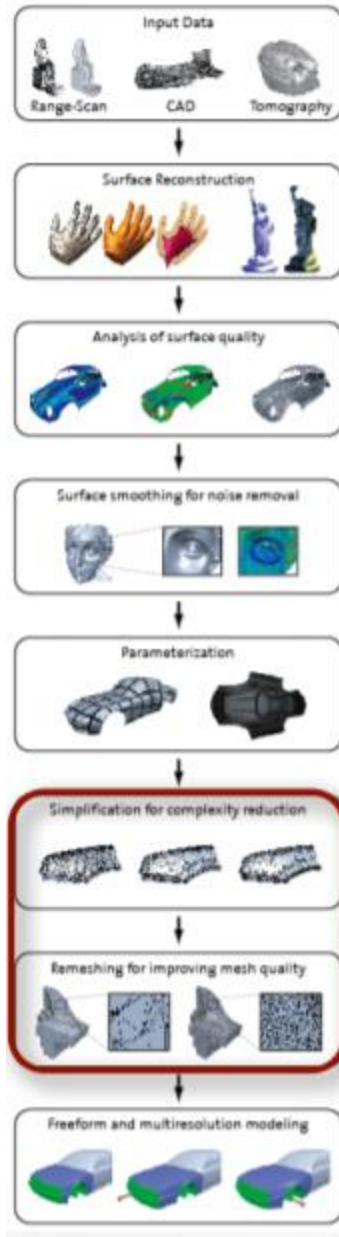
Parameterization



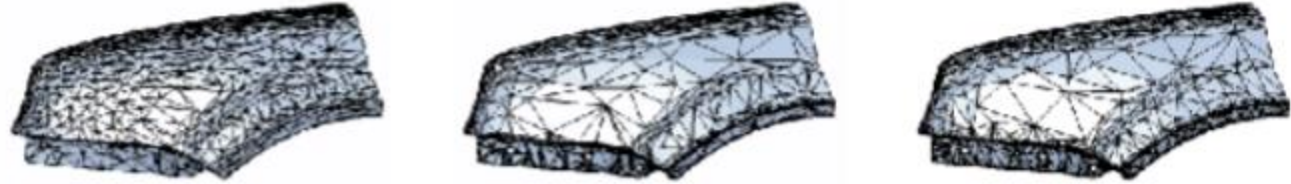
Geometry Processing Pipeline



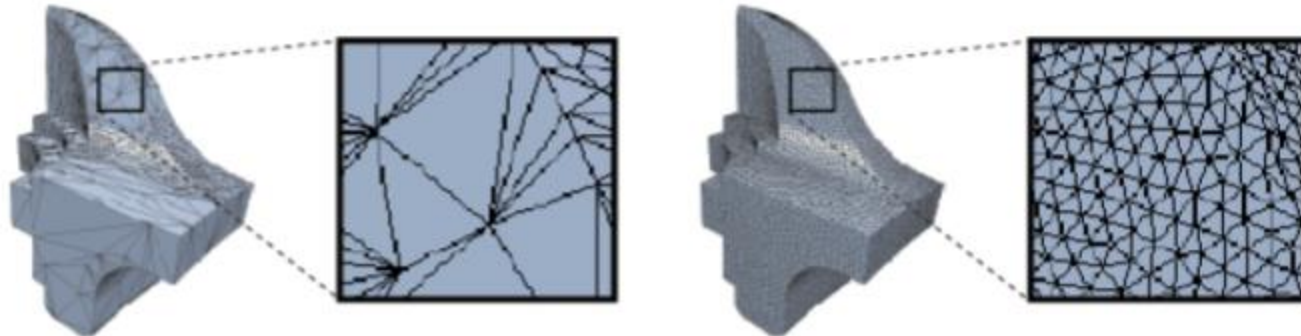
Geometry Processing Pipeline



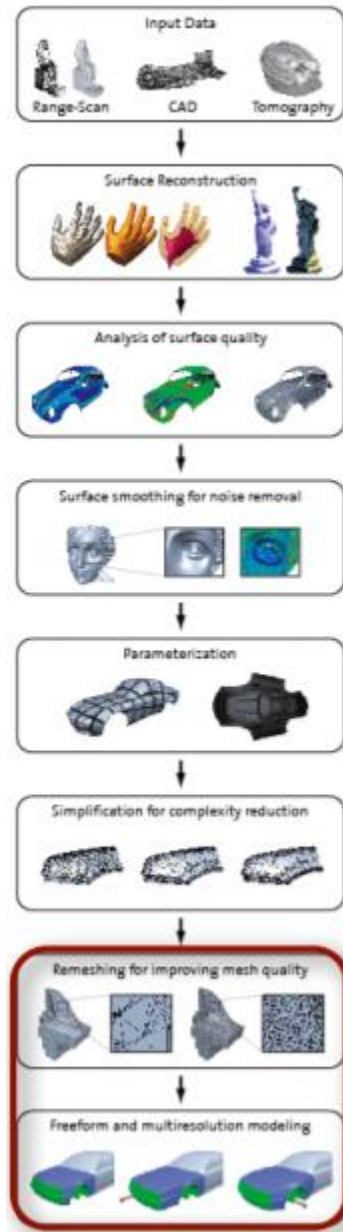
Simplification for complexity reduction



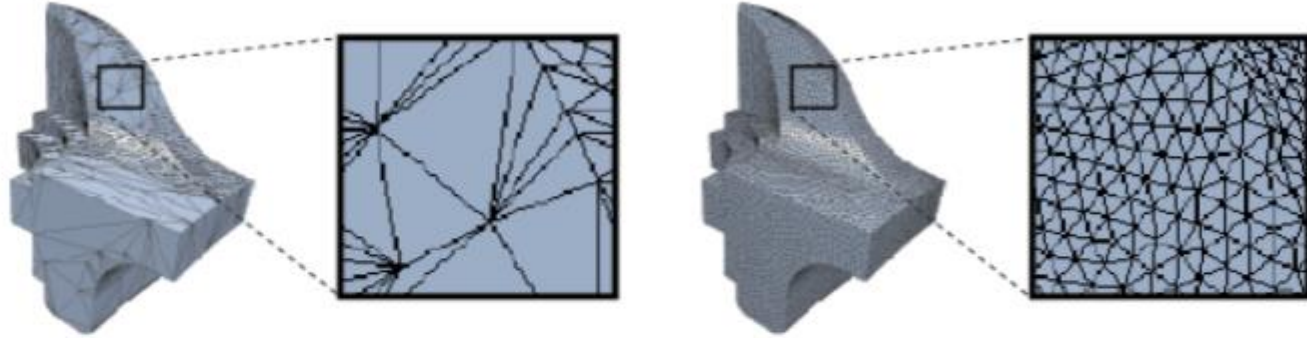
Remeshing for improving mesh quality



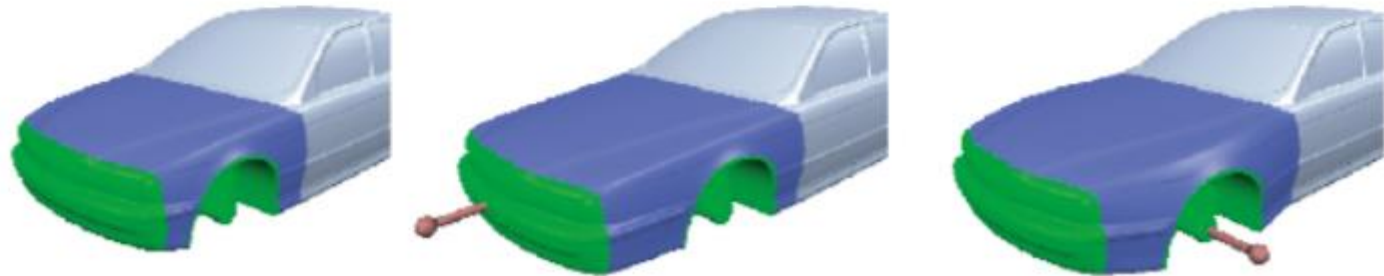
Geometry Processing Pipeline



Remeshing for improving mesh quality



Freeform and multiresolution modeling



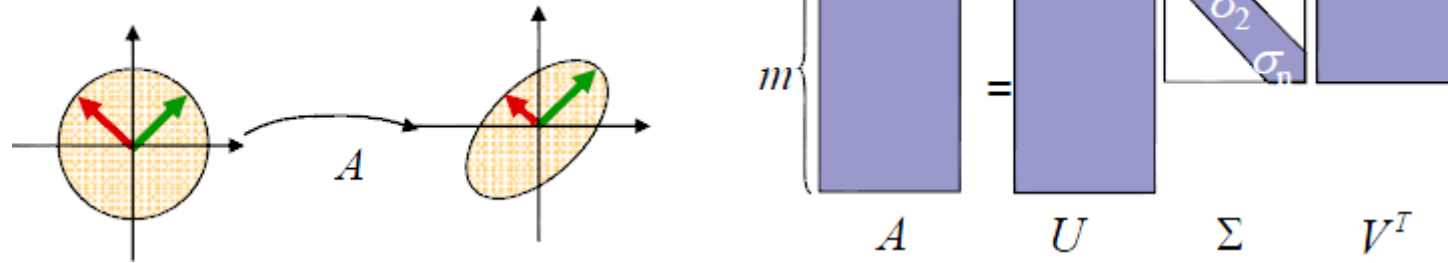
About the course

Target Audience

- PhD students, MSc students, Advanced undergraduates
- **Computer Science**, Computer Engineering, **Mathematics**, Physics, Game Program, Biomedicine, Bioengineering, etc.
- Computer Graphics, Computer Vision, Robotics, Machine Learning, Signal and Image Processing, Medical Imaging

Prerequisites

- Differential Geometry
- Linear algebra: transformations, spectral decomposition, PCA, SVD
- Graph theory
- ...



- **Combined with a lot of intuition ...**
- **Work on real data = Write/use a lot of code!**

Prerequisites

- Familiarity with a graphics API (e.g. OpenGL)
 - If not, learn quickly (for the sake of visualization)
 - <http://jjcao.github.io/ComputerGraphics/>
- C++/Matlab coding skills
 - If Java is preferred, you will be on your own
- Capability to search Google and forums for useful information

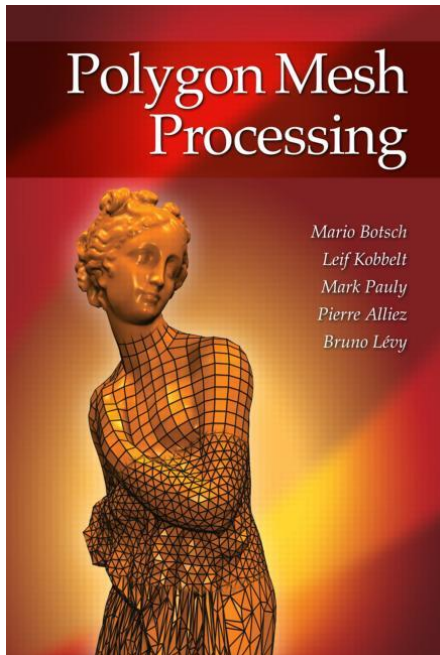
Coding

Coding is very import in this area!

**If you can not program, you will
study nothing in this subject!**

Recommended Textbooks

- Botsch, Kobbelt, Pauly, Alliez, Levy: Polygon Mesh Processing, AK Peters, 2010, <http://www.pmp-book.org/>
- A Sampler of Useful Computational Tools for Applied Geometry, Computer Graphics, and Image Processing, 2015



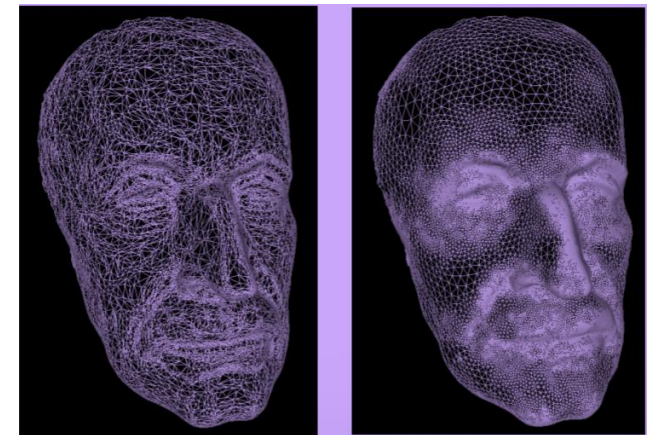
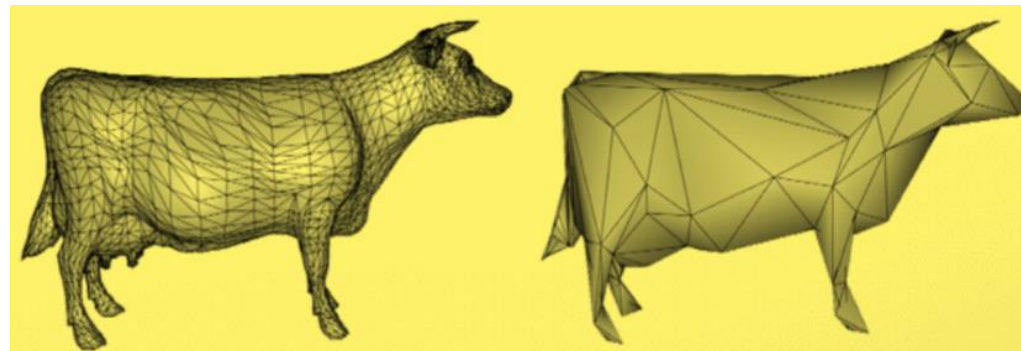
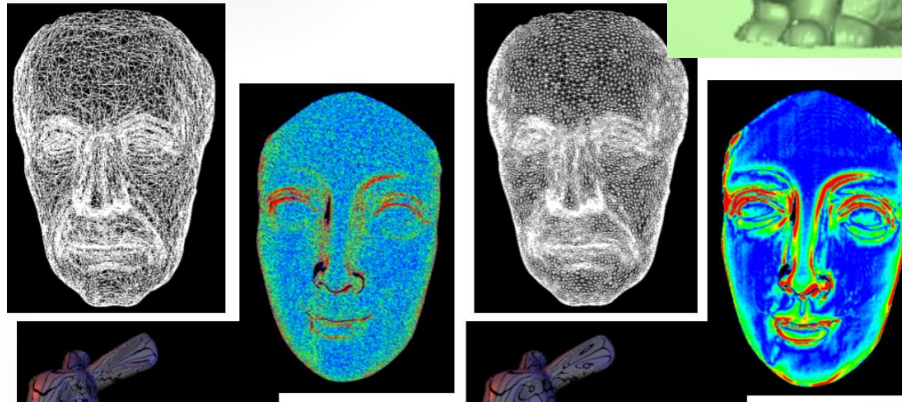
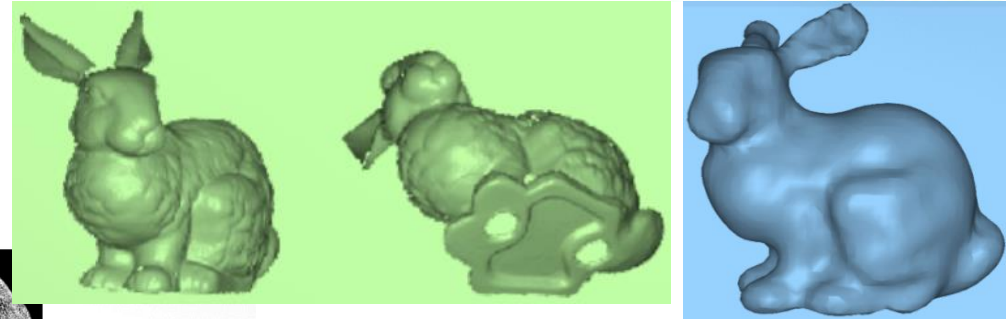
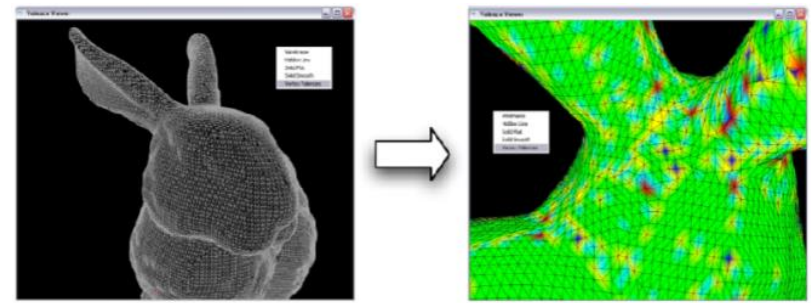
A Sampler of Useful Mathematical Tools for Applied Geometry

Daniel Cohen-Or (editor)
Chen Greif
Tao Ju
Niloy Mitra
Ariel Shamir
Olga Sorkine-Hornung
Hao (Richard) Zhang



Exercises

1. Introduction to **OpenMesh** (display mesh)
2. Registration
3. Implicit Surface Reconstruction
4. Surface Smoothing
5. Mesh Decimation
6. Remeshing



Grading

- Homework

- Contribute to **40%** of the final grade :
 - Document 20 + Compilable code 10 + Executable file 10
- 2-registration,3-reconstruction,5-decimation,6-remeshing to 8 groups

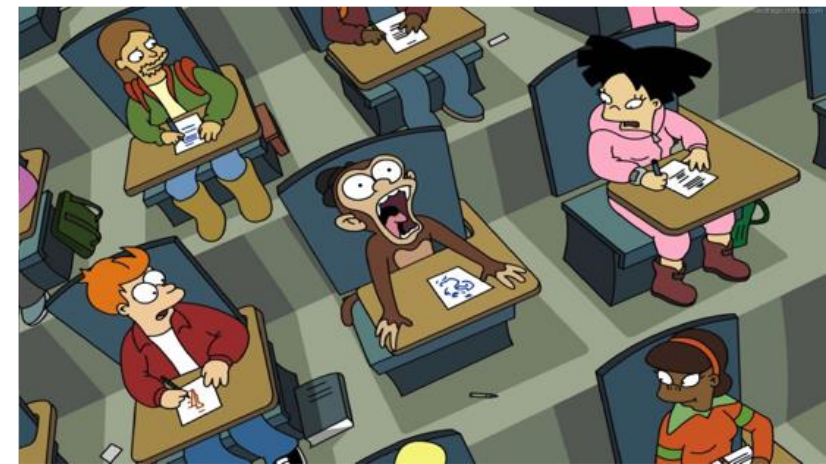
- Oral Reports:

- **10%(Paper)+10%(HW)**

- Class performance

- 20%

- Two students a team



Code in electronic:

- I can open *.sln and build it successfully and without modify setting and anything outside the folder.
- Compress whole folder into a zip
- Run **packing.bat** before compression
- Good function name and proper comments

Exe in electronic:

- A folder with exe, dll, and input data.
- Compress whole folder into a zip.

Document in A4 & electronic:
functions (required + optional)

RF1

Text description;

Code segment for the function

Image illustration;

...

OF1

Text description;

Code segment for the function

Image illustration;

Oral Reports:

- **10%(Paper)**
 - Problem solved
 - Contribution
 - Pros & cons
 - Core ideas
- **10%(HW)**
 - Show results (run software > show video > show pictures)
 - Report pipeline, main algorithms, main theory behind

Related courses @ dlut math

- C++ <http://jjcao.github.io/cPlusPlus/>
- Computer Graphics <http://jjcao.github.io/ComputerGraphics/>
- 2120040081, Digital Media Processing, 数字媒体处理方法选讲
- 3120033010, New Topics in Computational Geometry, 计算几何新专题

Course Objectives

- **Relate** the basic concept, tools, and algorithms in geometric modeling and digital geometry processing
- **Design** and **implement** individual components of geometric modeling system
- **Apply** the proposed methods in your own work

Video demos

Thanks

Acknowledgement

- **Course material taught at:**
 - University of Southern California, Hao Li