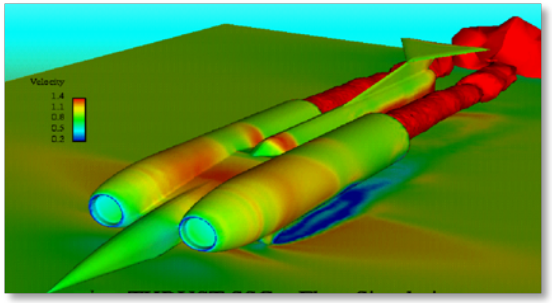
G22.3033-008, Spring 2010

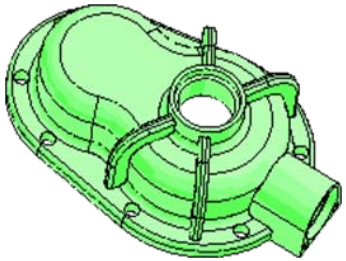
Geometric Modeling

Introduction and Overview

Geometric Modeling

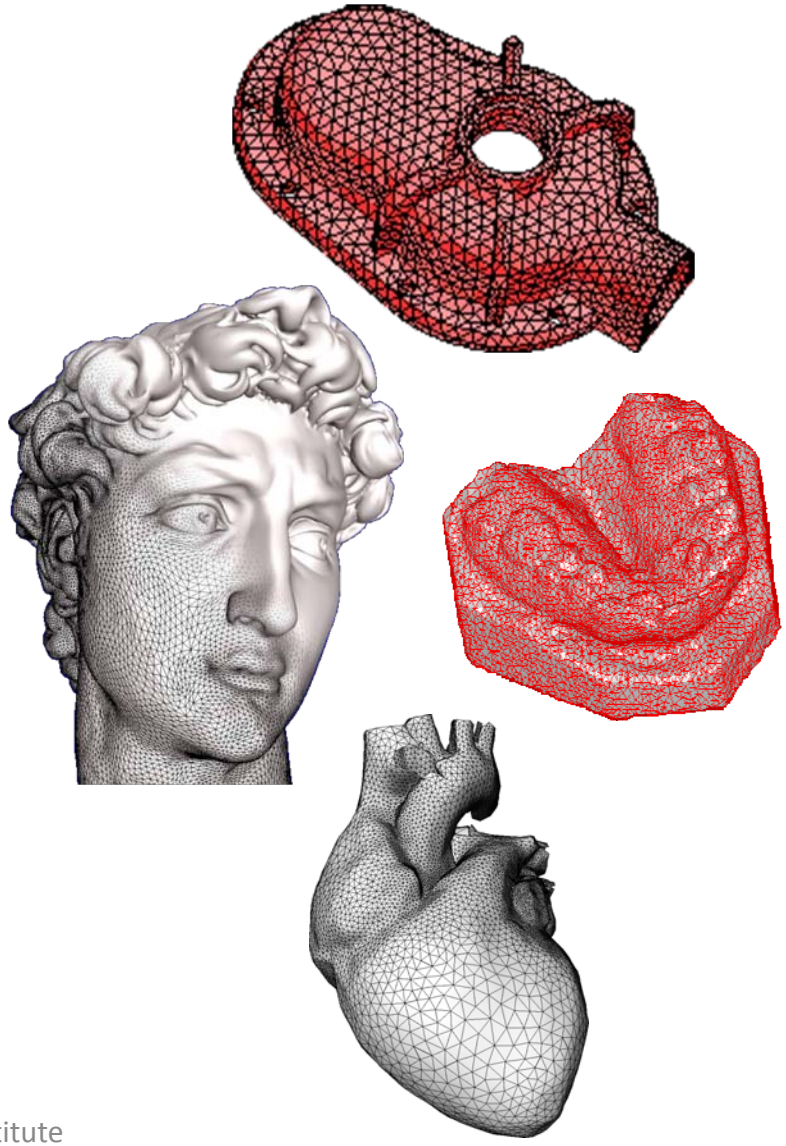
- To describe any real-life object on the computer – must start with shape (2D/3D)
- Geometry processing: computerized modeling of 2D/3D geometry





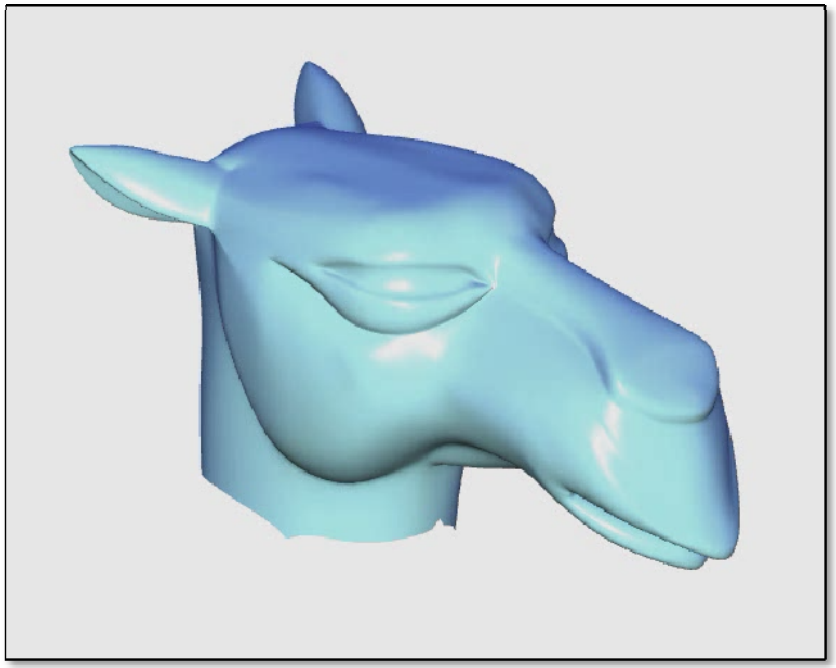
Digital Geometry Processing (DGP)

- Processing of discrete (polygonal mesh) models
  - Typically triangular
- Why discrete?
  - Simplicity – ease of description & transfer
  - Base data for rendering software/hardware
  - Output of most acquisition tools (CT, MRI, laser, etc..)
  - Input to most simulation/analysis tools



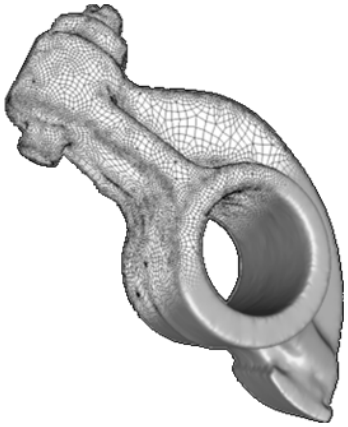
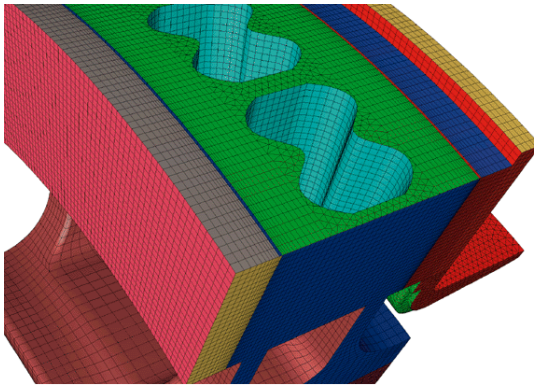
Interactive shape modeling

- Tools for design and editing of digital shapes
  - Interactive means fast algorithms
  - Intuitive – expected outcome

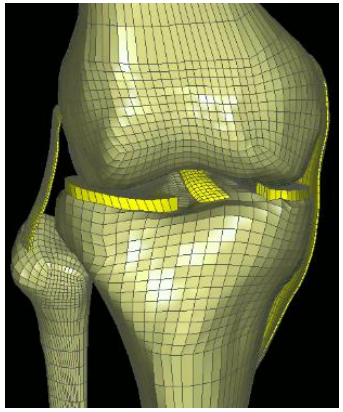


Applications

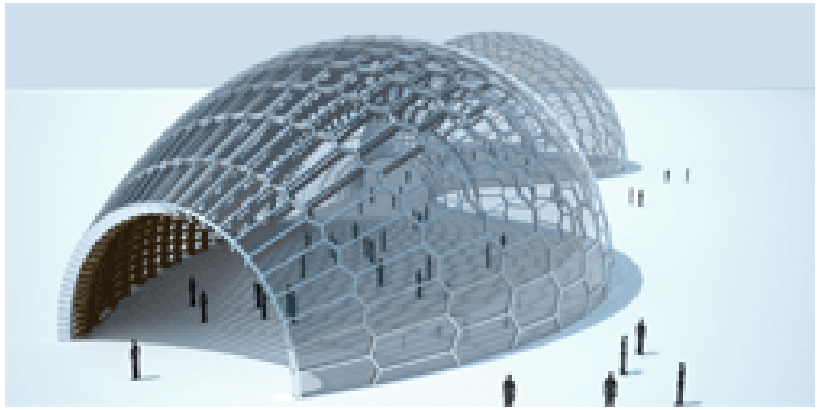

Games/Movies

Engineering



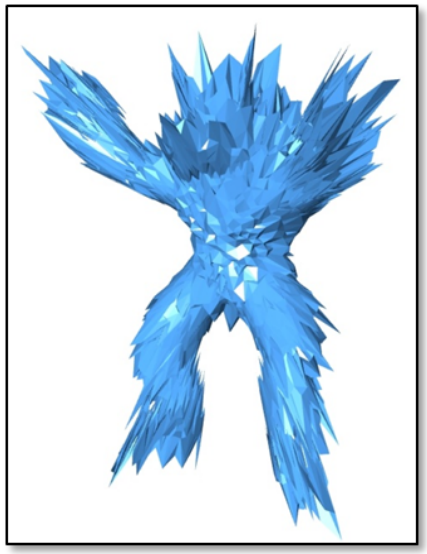

Medicine/Biology



Architecture

Tools?

- Use techniques from both Math & CS
  - Differential geometry
  - Numerical linear algebra
  - Graph theory
  - …
- …Combined with a lot of intuition…
- Work on real data = Write/use a lot of code ☺



Organization

- Olga Sorkine
  sorkine@cs.nyu.edu
  http://www.cs.nyu.edu/~sorkine/
- Office hours: Thursdays, 5-6pm, Room 1204
  or other time (coordinate via e-mail)

Organization

- Course website (also linked from my homepage) http://www.cs.nyu.edu/courses/spring10/G22.3033-008/index.html
- Mailing list: g22_3033_008_sp10@cs.nyu.edu
- Check the website often for updates!

Organization

Course materials

- No book covers all topics
  - Many of the topics are recent research results ☺
- I will link to relevant papers, presentations and tutorials on the course website
- Lecture slides will be available on the website shortly before the class
- Papers from: ACM SIGGRAPH, Symposium on Geometry Processing (SGP), Shape Modeling International (SMI), Eurographics, see **http://kesen.huang.googlepages.com/**

Prerequisites

- Familiarity with basic calculus, linear algebra, and vector calculus
- Familiarity with a graphics API (e.g. OpenGL)
  - If not, learn quickly
- C/C++/Java coding skills, programming applications with some GUI
- Capability to search Google and forums for useful information ☺

Course Overview

Topics

- Shape representations in computer graphics
  - Parametric (Bezier, splines), implicits, meshes + related data structures
- Shape acquisition and reconstruction
- Linear algebra tools for geometric modeling
- Differential geometry (normals, curvatures, …)
- Digital geometry processing (smoothing etc.)
- Shape deformation (space- and surface-based)

Grading

- 5 programming homework assignments (70%)
  - Next week: warp-up exercise on Bezier curves
  - 2/10: mesh “hello world”
  - 2/24: surface reconstruction with marching cubes
  - 3/10: calculation of discrete differential quantities on meshes
  - 3/24: interface for mesh editing (selection)

Grading

- 5 programming homework assignments (70%)
  - The assignments will be supplemented by theoretical questions
  - You will submit a report, screenshots and code
  - In special cases (e.g., I didn't manage to run your code) demo of the assignment during office hours

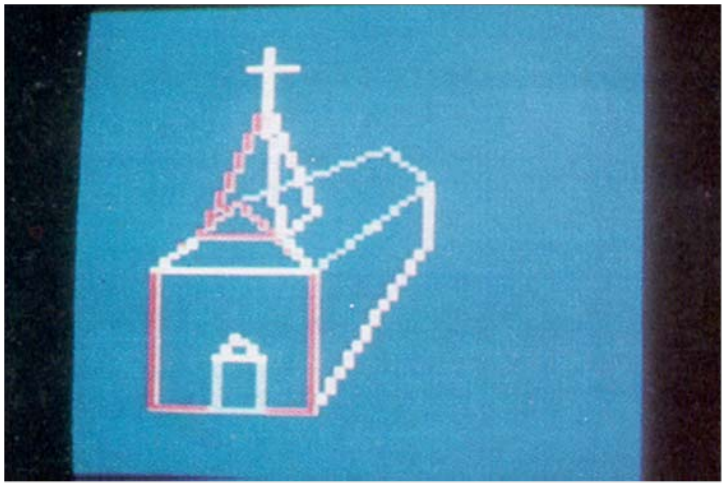
Grading

- 30% - Final project (start on 4/7 or earlier)
  - Use your mesh framework to implement:
    - An advanced digital geometry processing technique
    - And an interactive editing technique
  - Can pick from the methods we learned in class, and I will make suggestions as well
  - Can come up with a new technique! Opportunity to try research
  - Submit a report + code; demo in class on 4/28

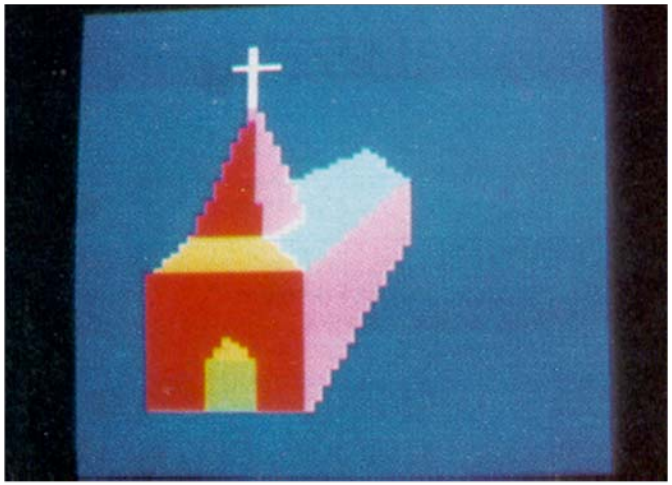
Computer Graphics

The big picture

- 3D graphics programming in 1979



approx. 25 triangles

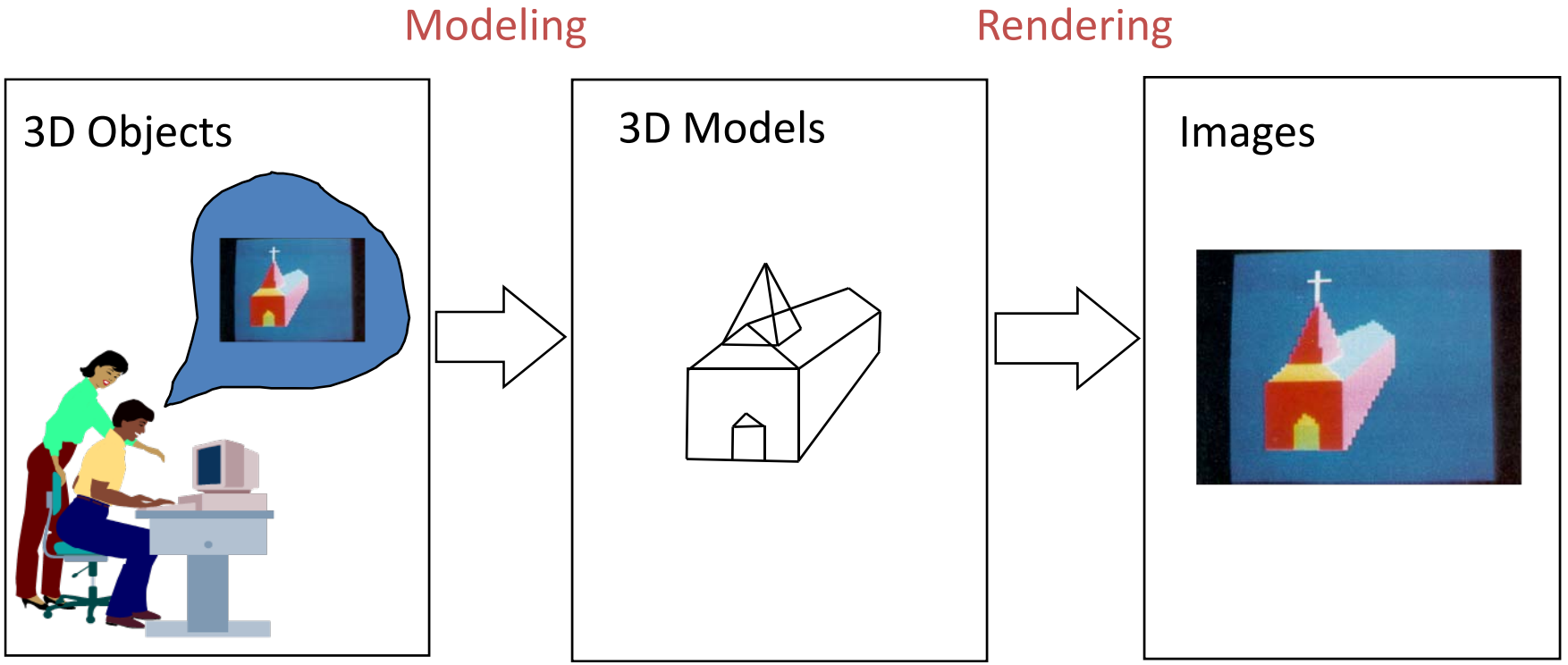


approx. 50 x 100 pixels

Computer Graphics

The big picture

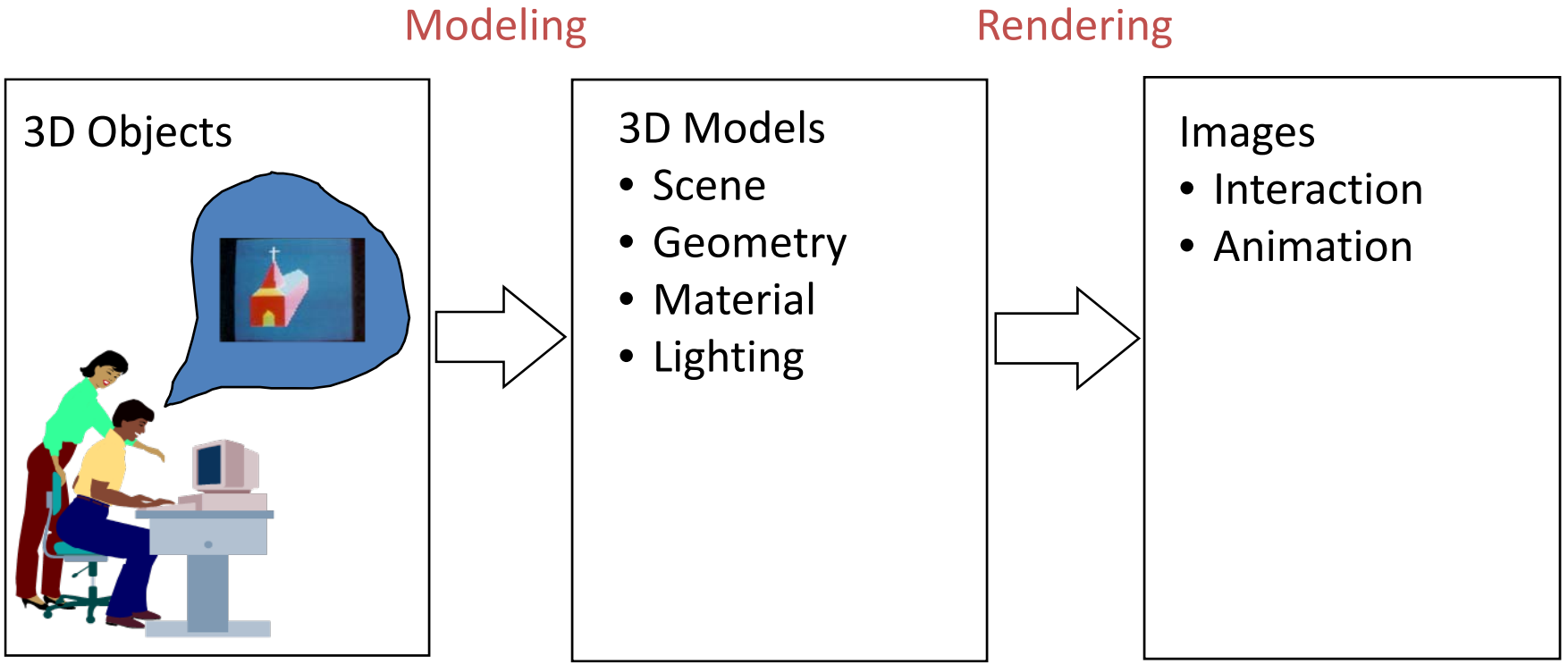
- Common workflow



Computer Graphics

The big picture

- Common workflow



Computer Graphics

The big picture

- Common wo

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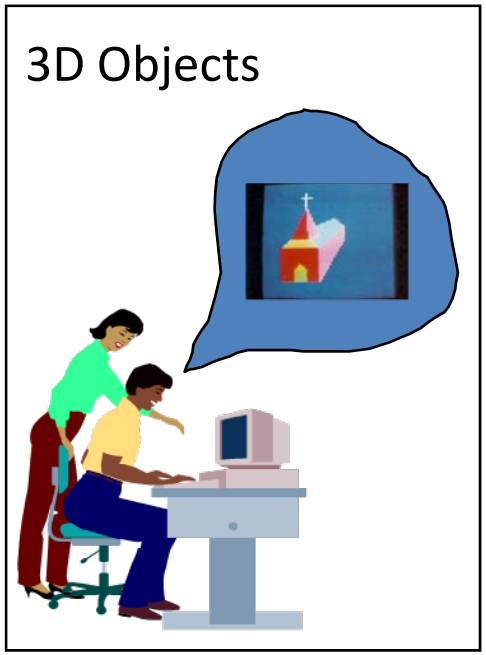
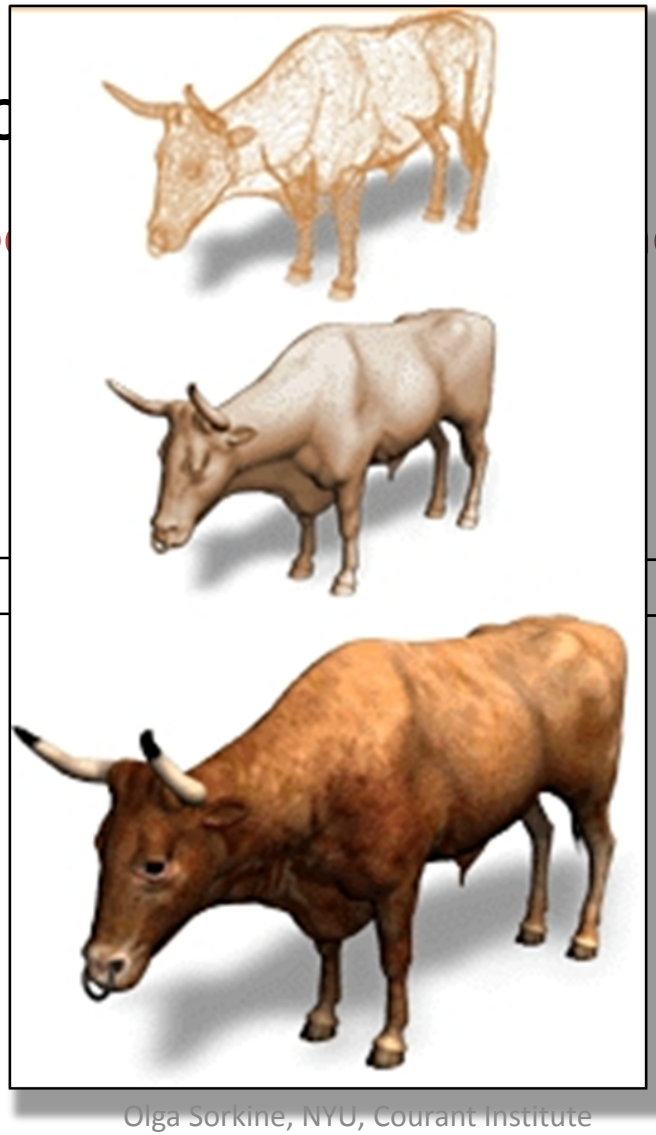


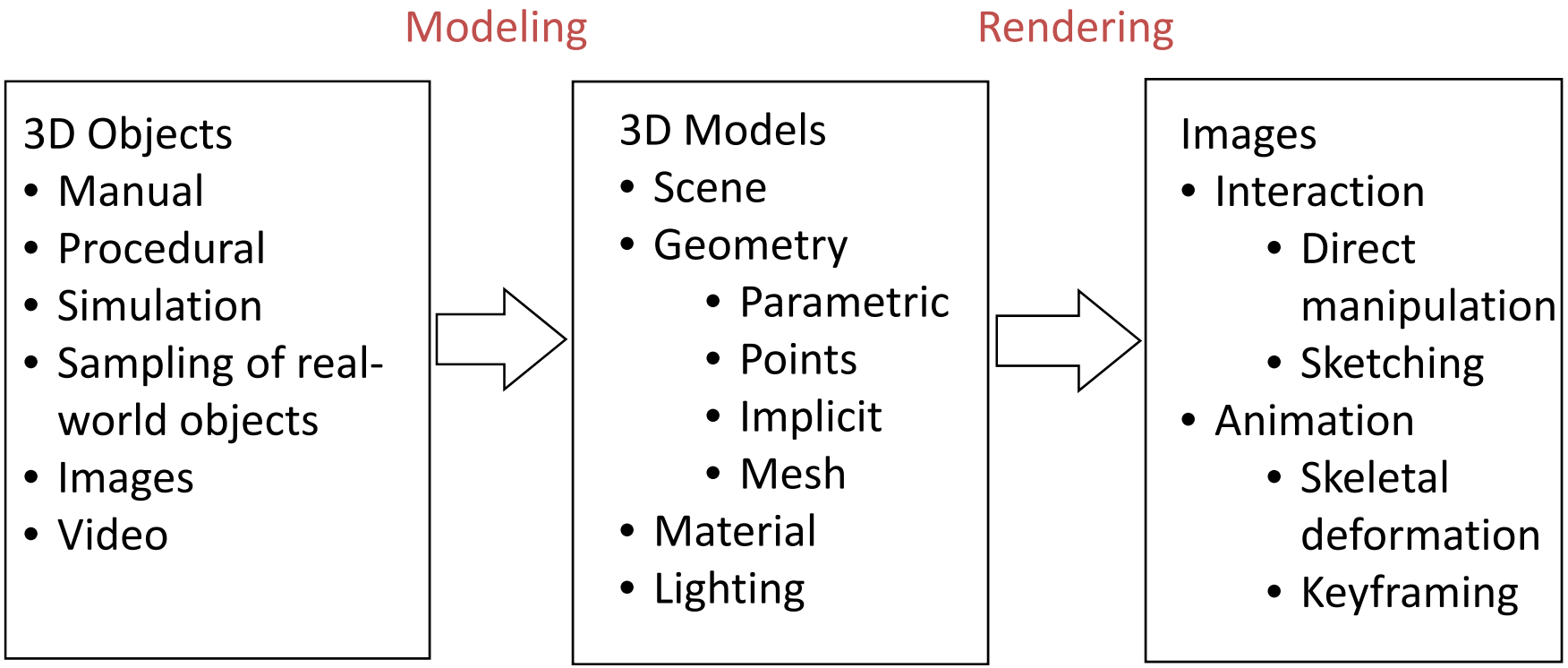


Images
- Interaction
- Animation

Computer Graphics

The big picture

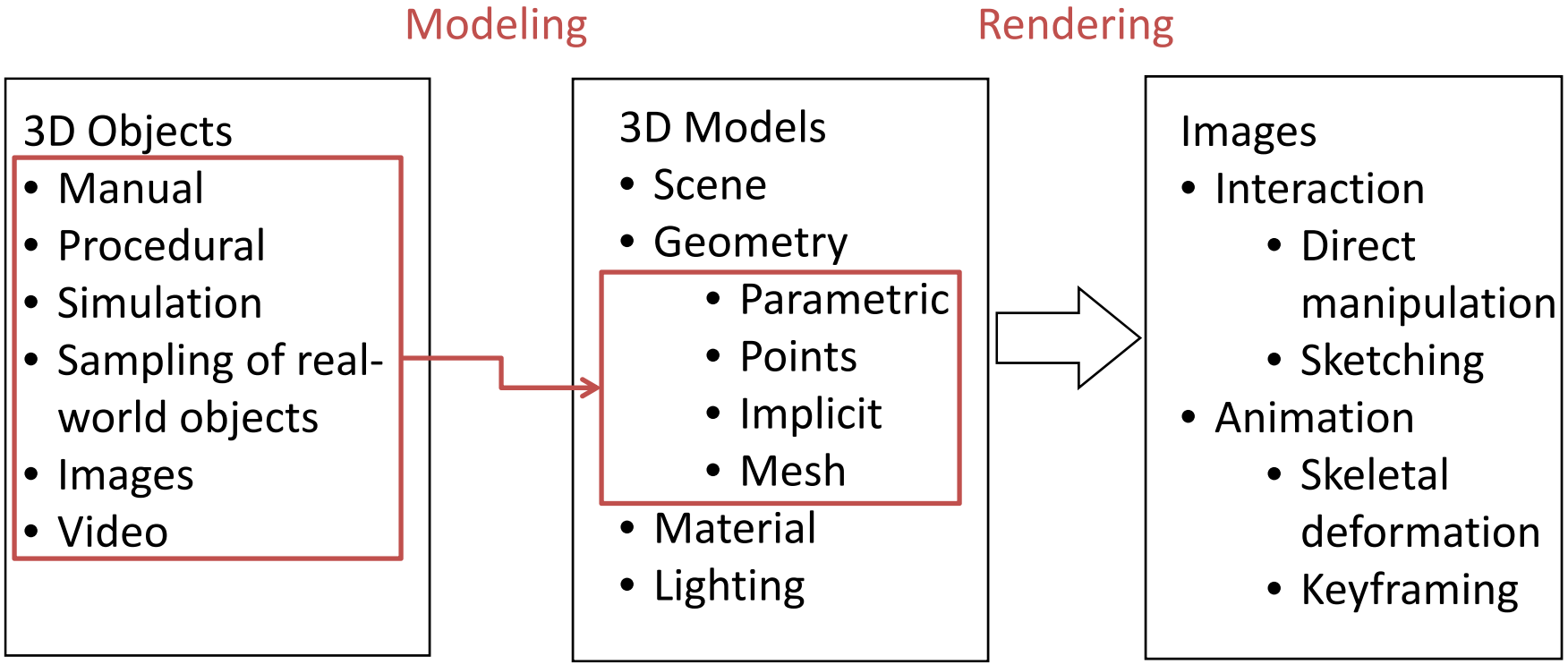
- Common workflow



Computer Graphics

The big picture

- Model creation



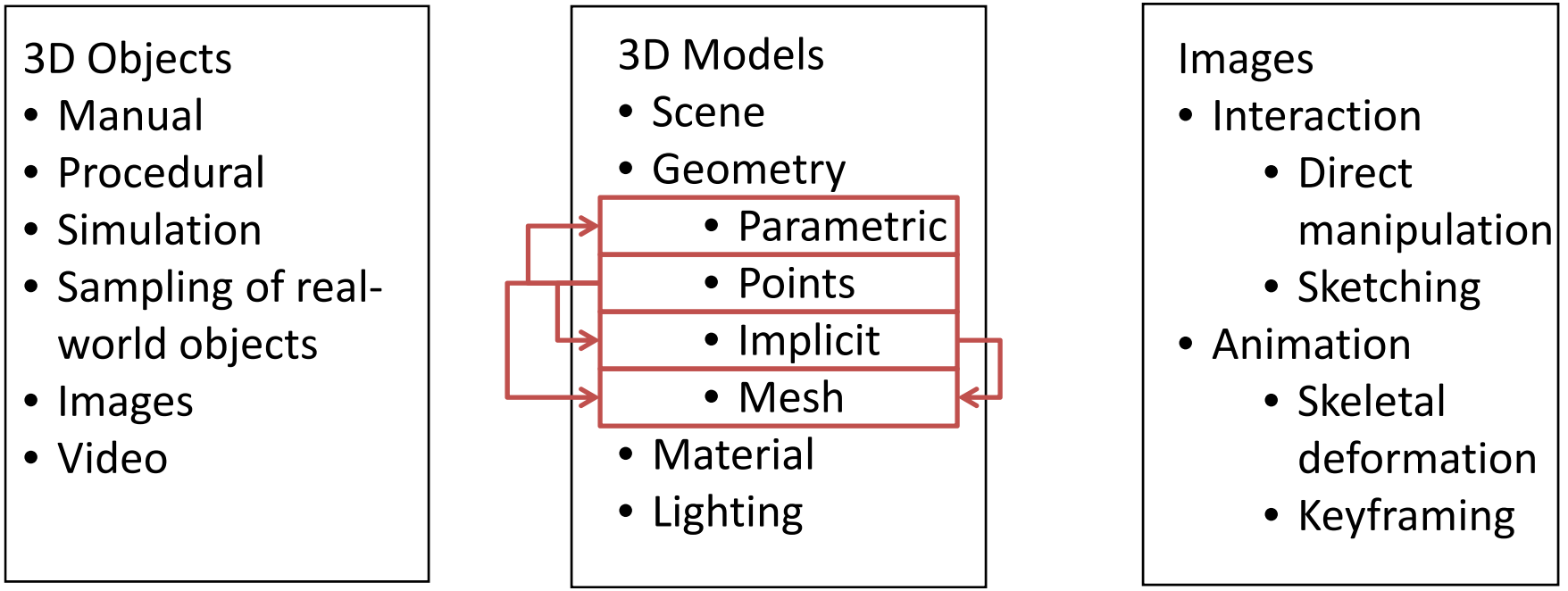
Computer Graphics

The big picture

- Model representation and conversion

Modeling

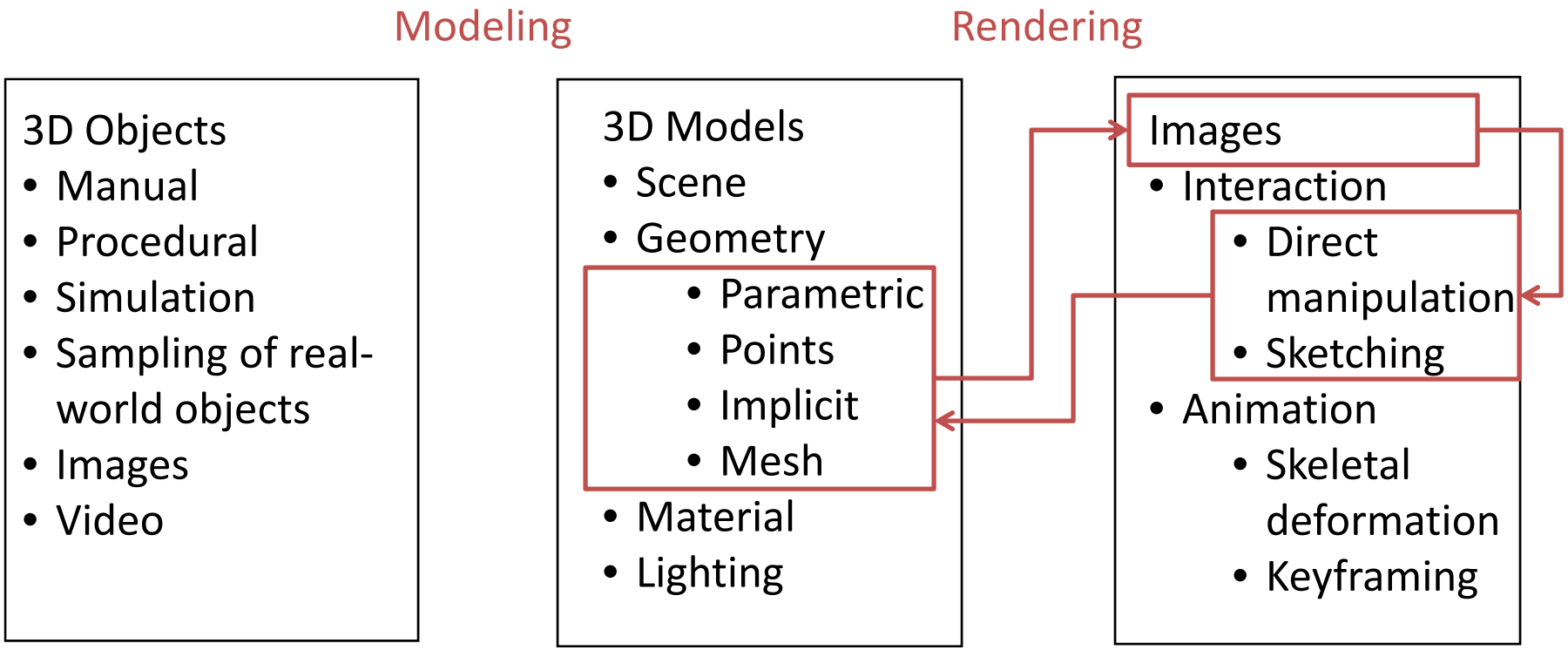
Rendering



Computer Graphics

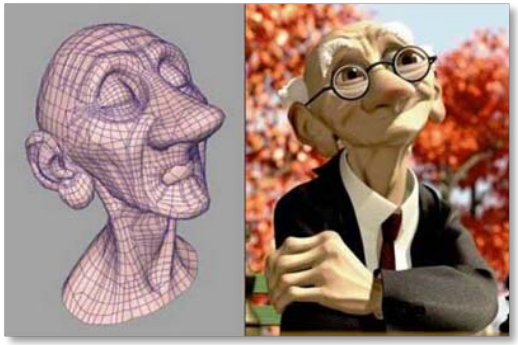
The big picture

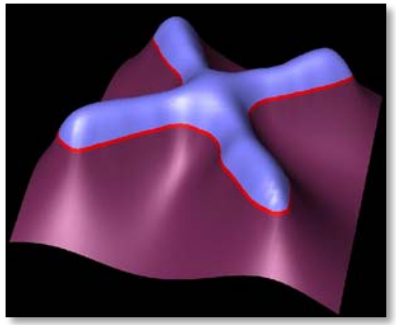
- Model modification and editing loop

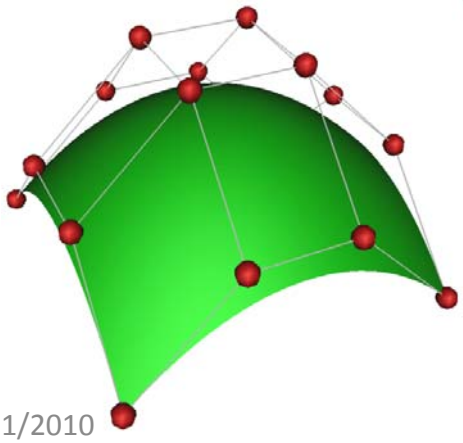


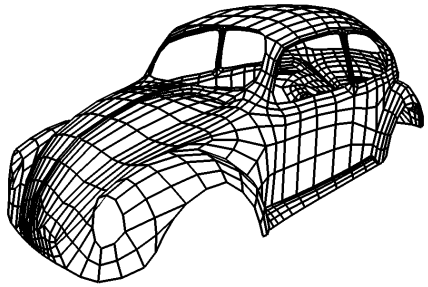
Course Topics

- Shape representation
  - Parametric curves/surfaces
  - Subdivision surfaces
  - Implicits



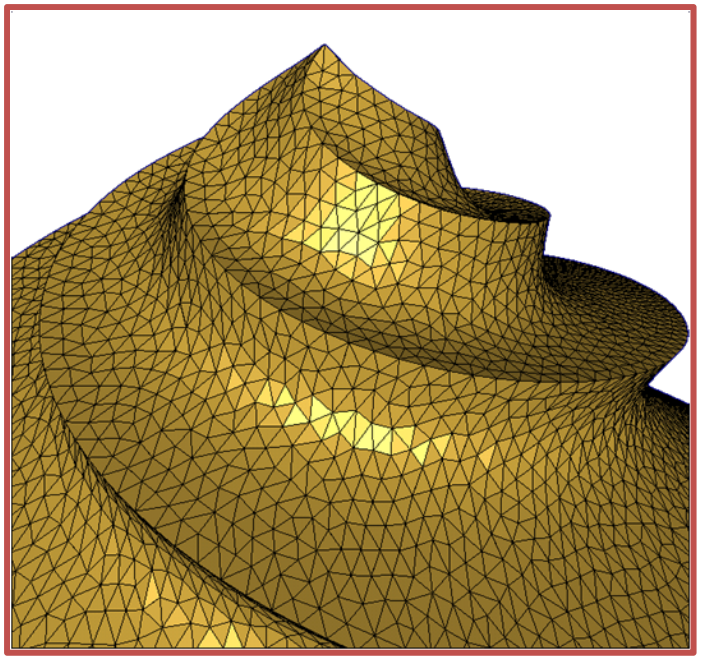


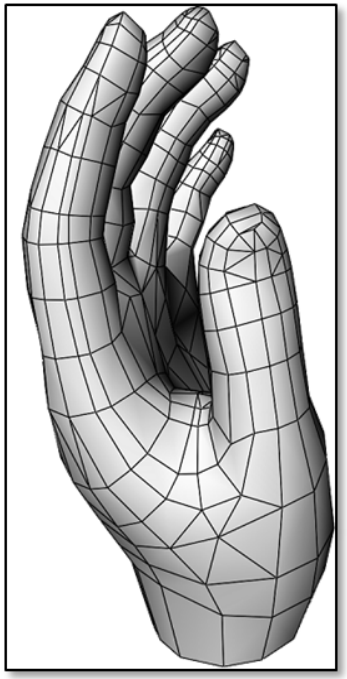


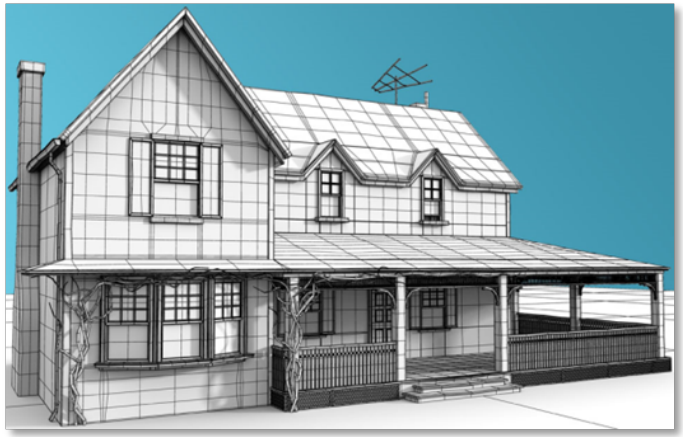


Course Topics

- Shape representation
  - Polygonal meshes

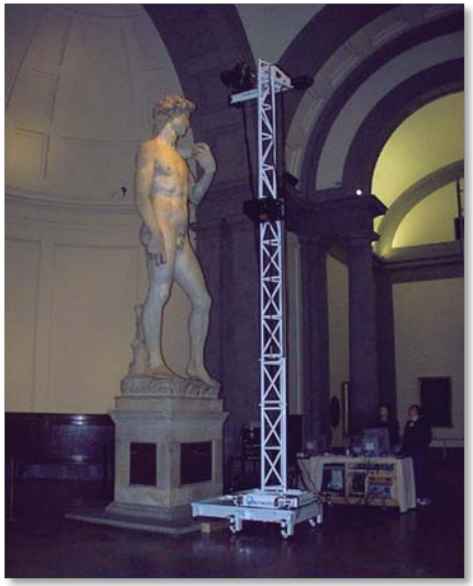


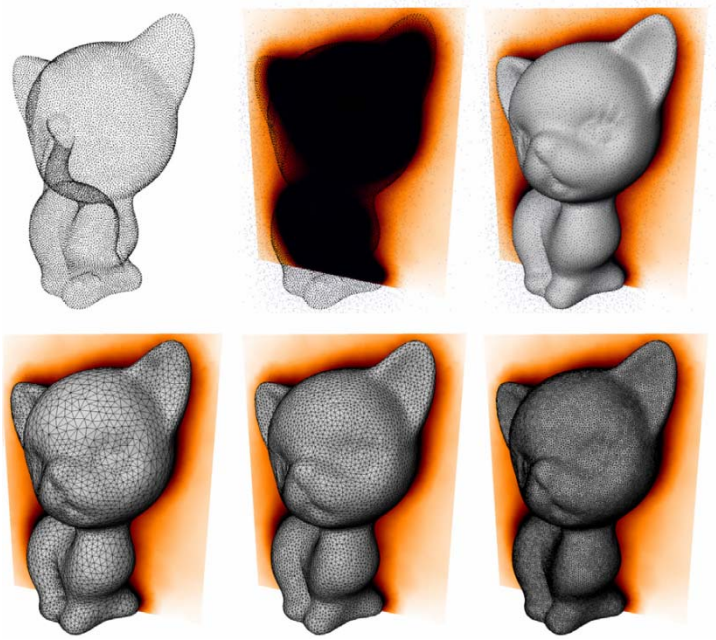


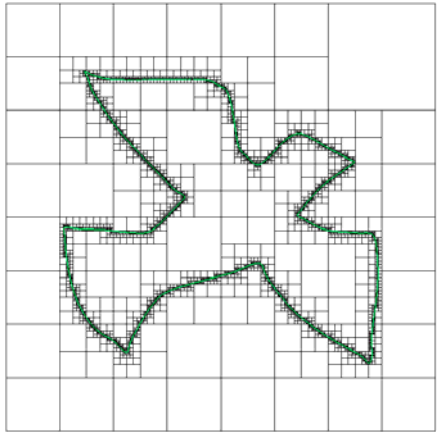


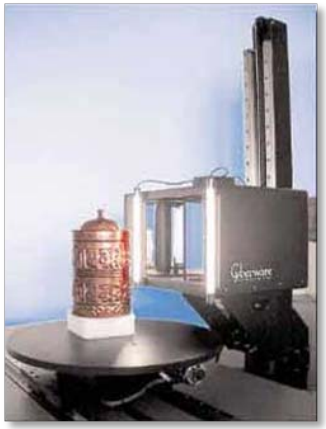
Course Topics

- Shape acquisition
  - Scanning/imaging
  - Reconstruction



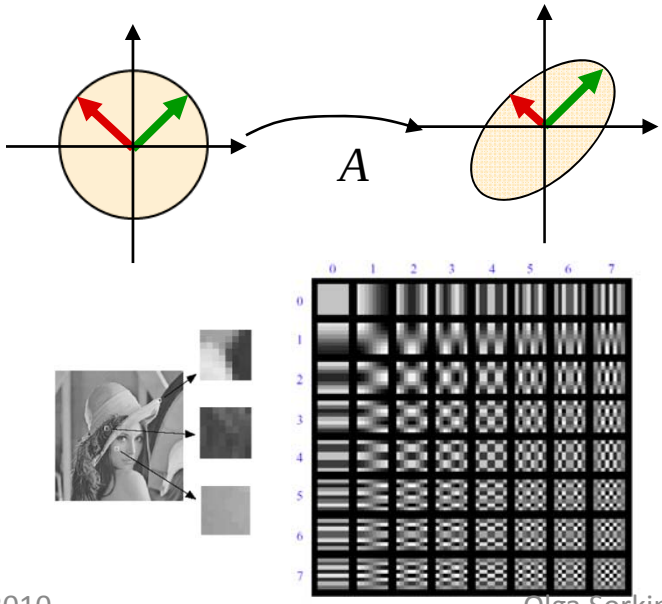


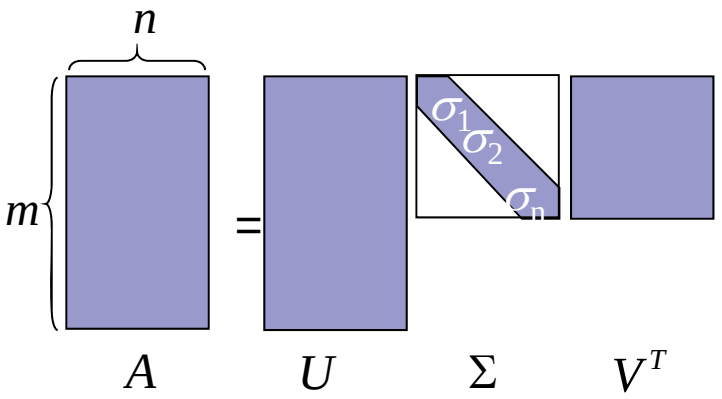




Course Topics

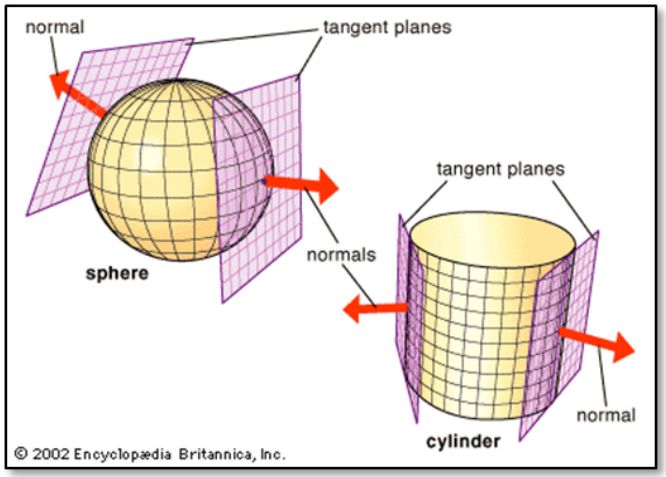
- Mathematical tools
  - Revisit linear algebra: transformations, spectral decomposition, PCA, SVD
  - See where these are used!

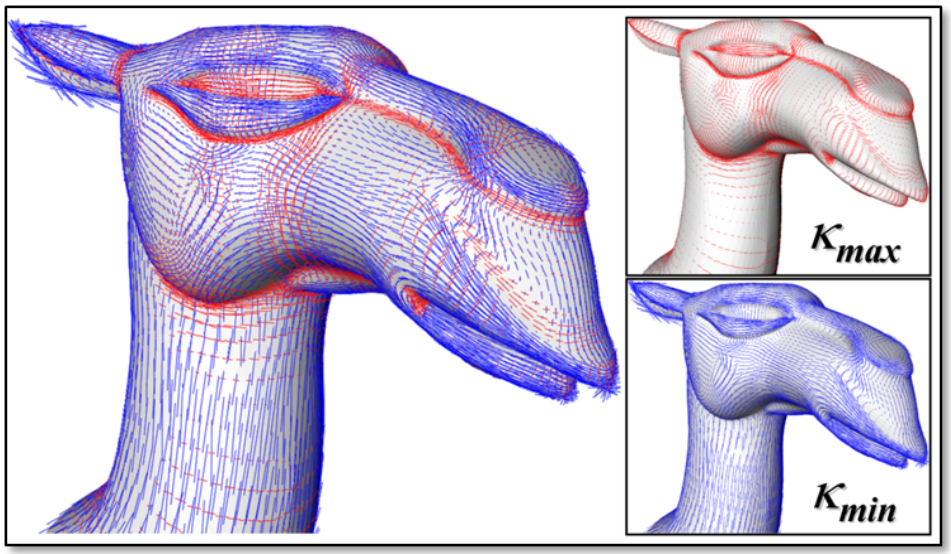




Course Topics

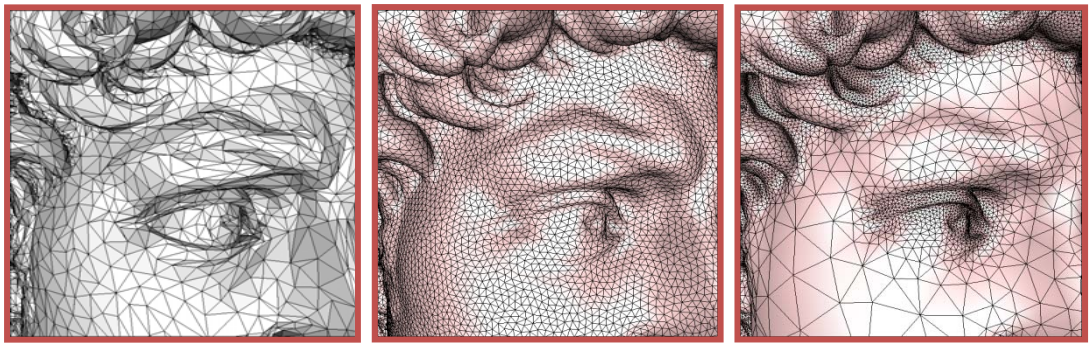
- Mathematical tools
  - Differential geometry – continuous and discrete
  - Our main tool to analyze and understand shapes

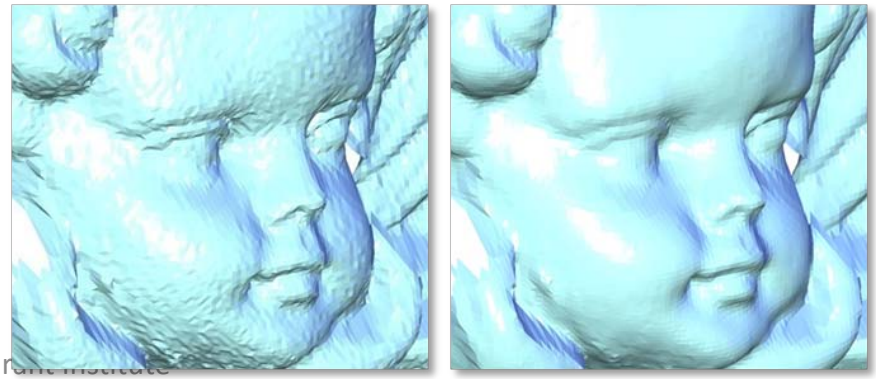




Course Topics

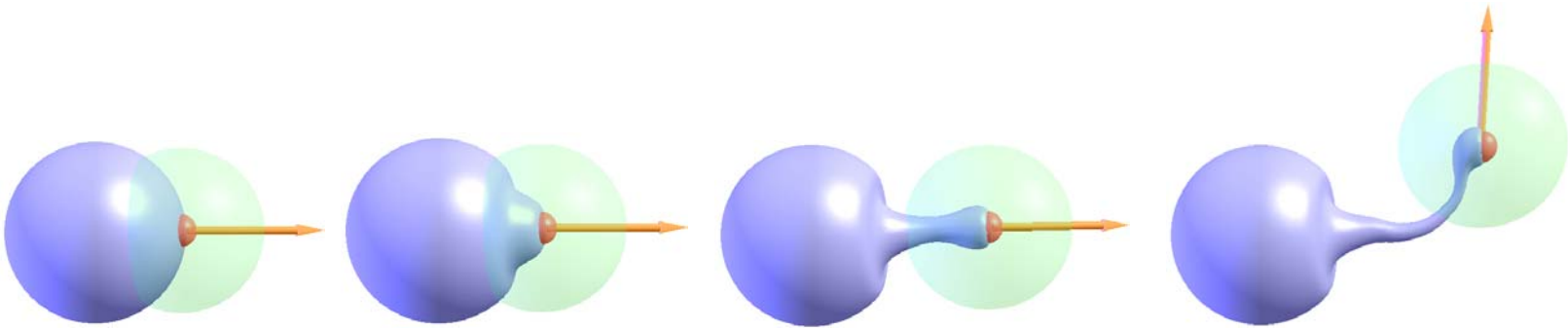
- Digital geometry processing
  - Denoising, smoothing, simplification/remeshing, parameterization, compression

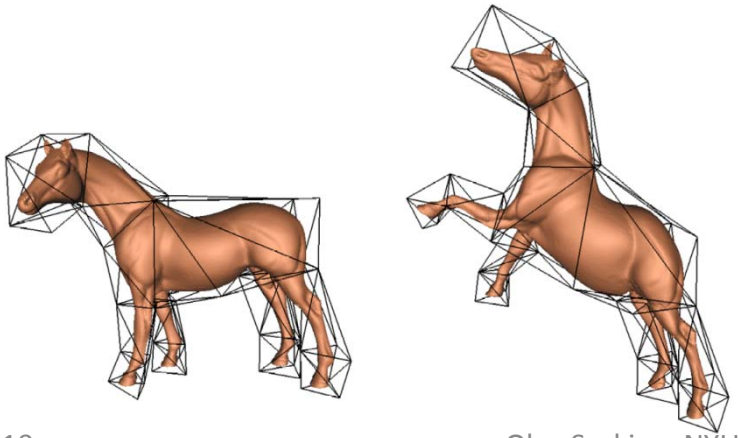


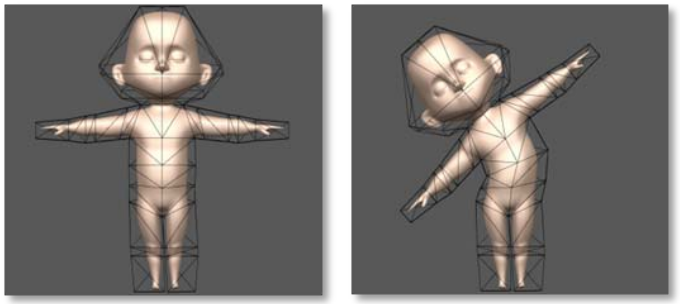


Course Topics

- Shape modeling and deformation
  - Space warps/ Freeform deformations

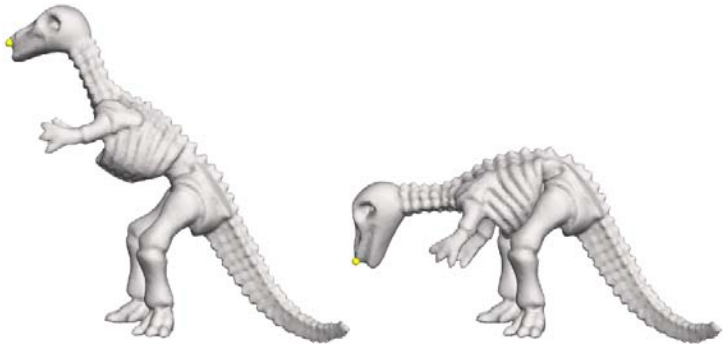


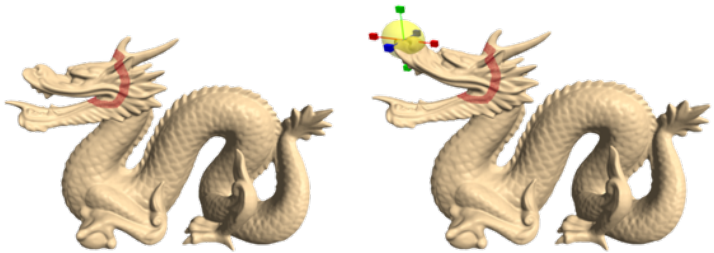


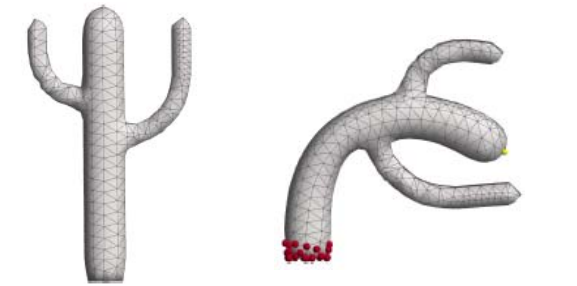


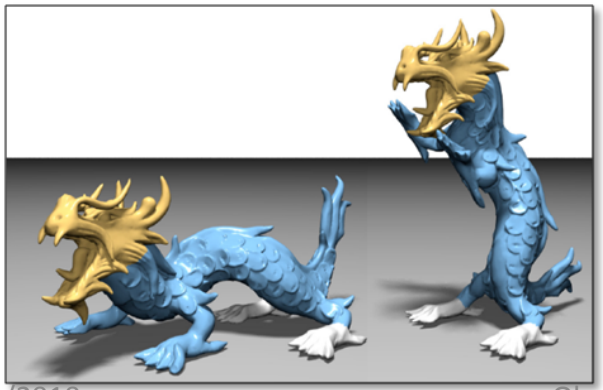
Course Topics

- Shape modeling and deformation
  - Surface-based deformations



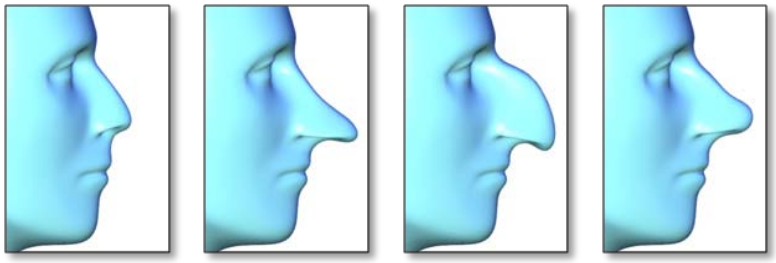


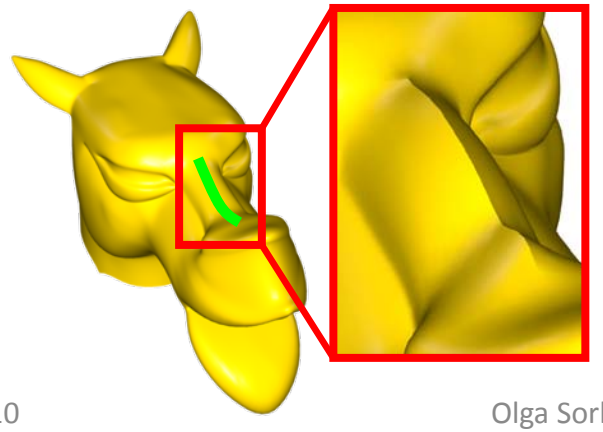


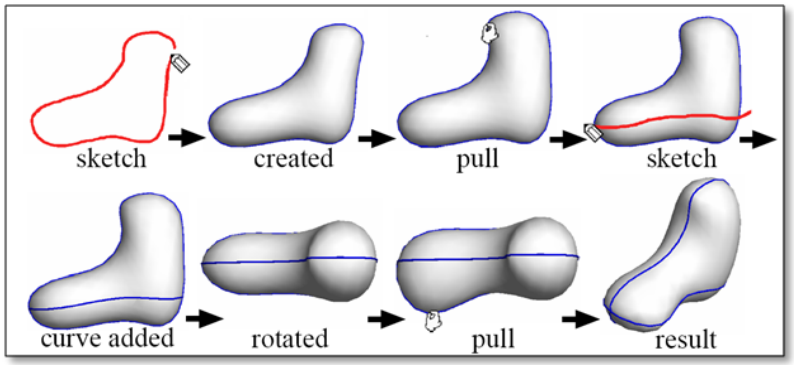


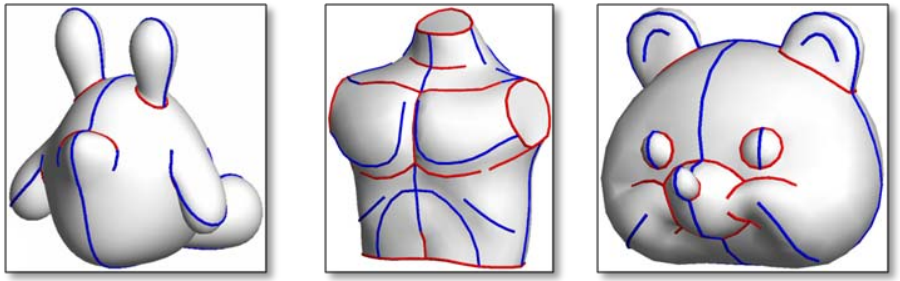
Course Topics

- Sketch-based interfaces
  - Shape creation
  - Shape editing



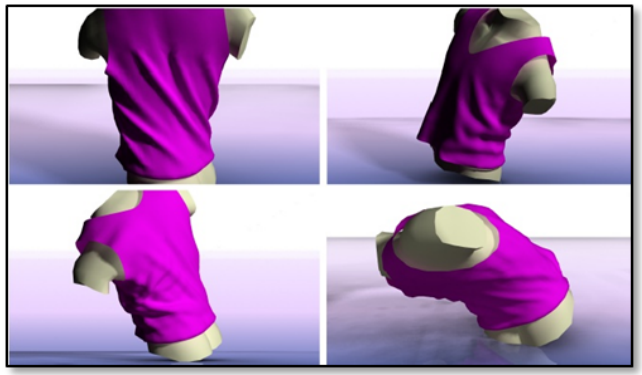


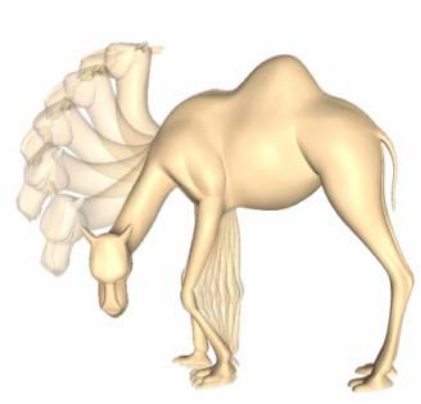




Course Topics

- More applications of geometric deformation
  - Skeleton-skin animation; morphing
  - Image/video retargeting





Thanks