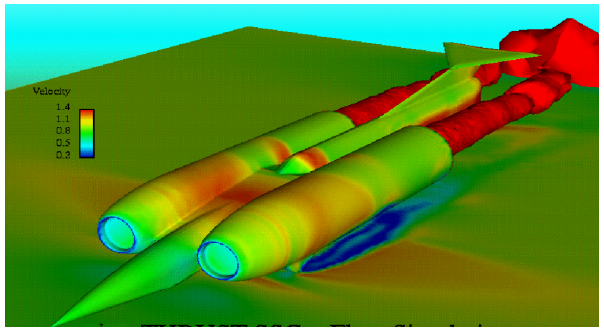
CS 523: Computer Graphics, Spring 2011

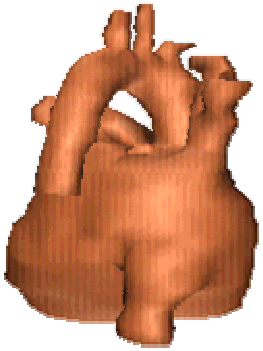
Shape Modeling

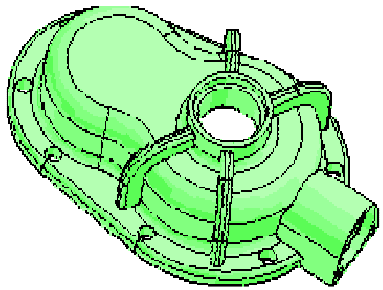
Introduction and Overview

Geometric Modeling

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

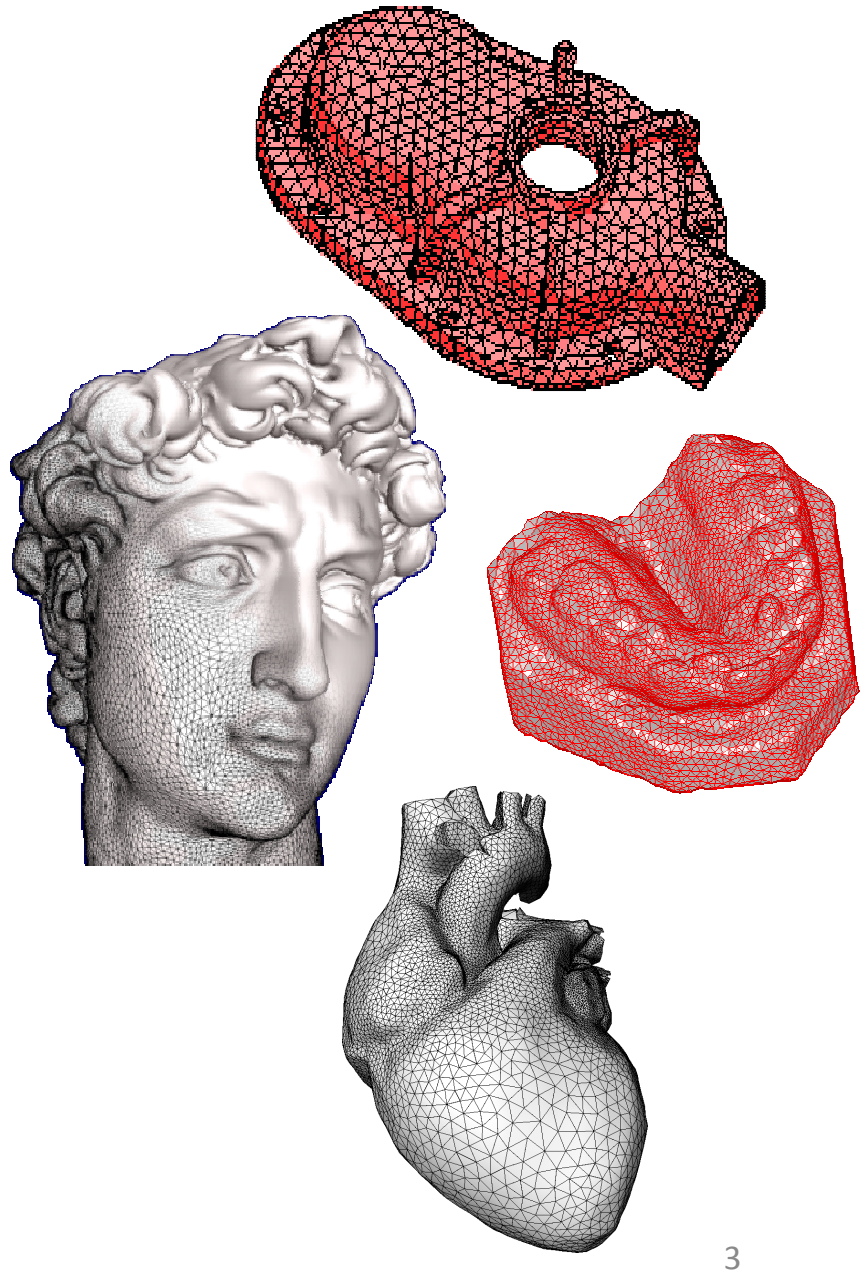






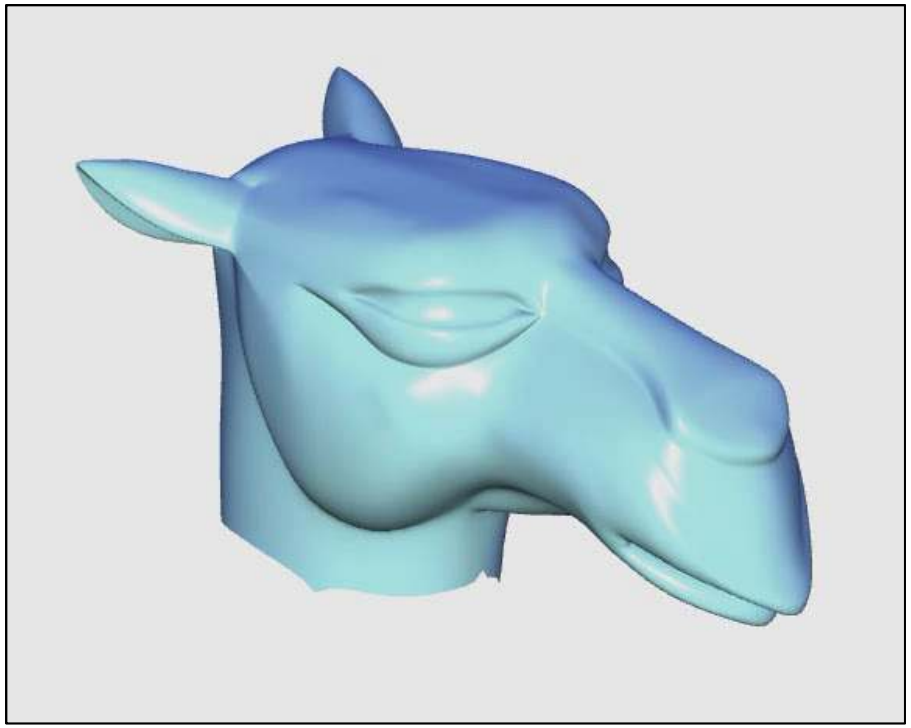
Digital Geometry Processing

- 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



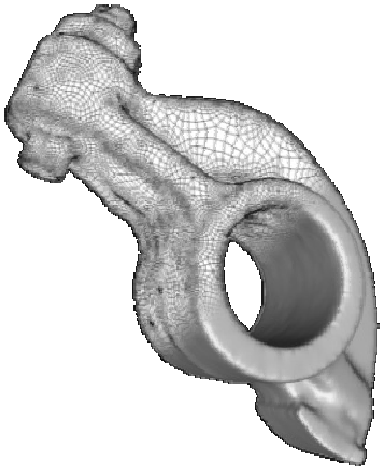
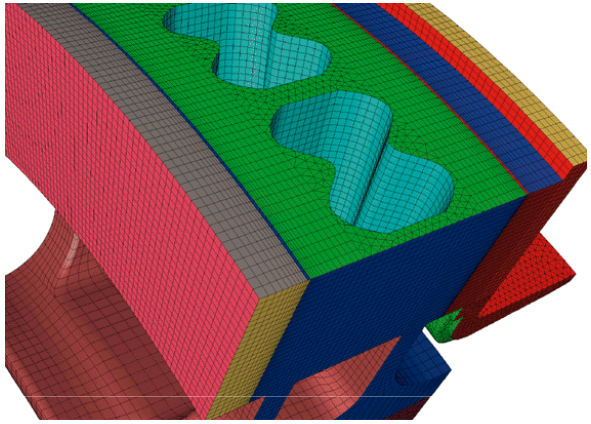
Interactive shape modeling

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

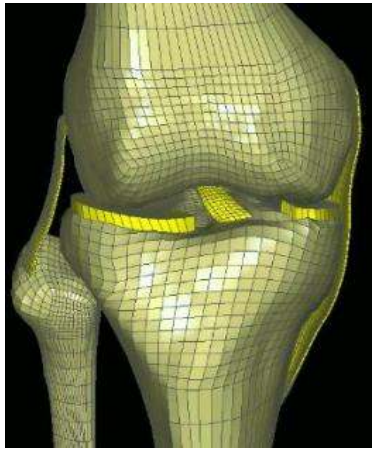
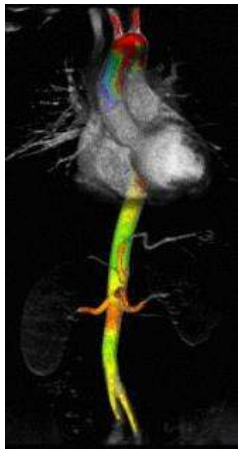


Applications

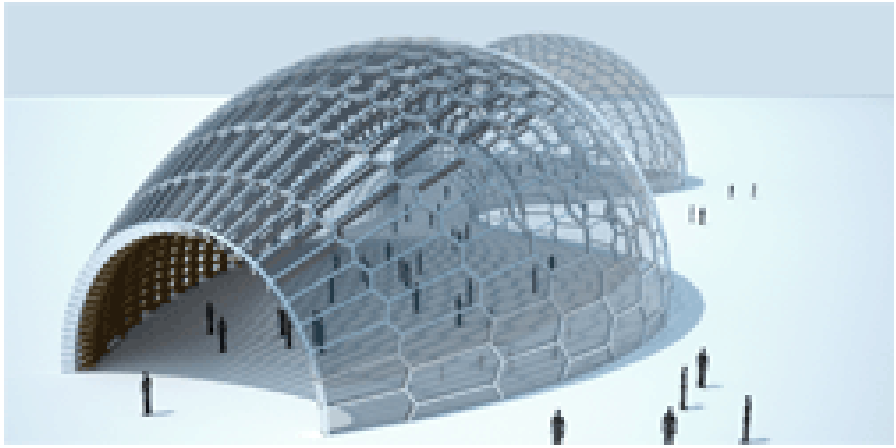

Games/Movies

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

People

- Andrew Nealen
  CBIM, room 21
  nealen@cs.rutgers.edu
  http://www.cs.rutgers.edu/~nealen
  Office hours: Tuesday, 4-6pm

- Teaching assistant
  Ming Jin
  mjin@cs.rutgers.edu
  Office hours: TBA

Organization

Web and communication

- Course website (external access to Wiki)
  `https://sakai.rutgers.edu/wiki/cs523-spring2011/home.html`
- Wiki, archived mails, forum, resources, etc...
  `http://sakai.rutgers.edu`
- Use mailing list
  `cs523-spring2011@sakai.rutgers.edu`
  and **Sakai forum** for communication

Organization

Course materials

- We are using a textbook (Botsch et al.)
  - But 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 web shortly before each class
  - Makes sense to annotate them during the lectures

Prerequisites

- Familiarity with basic calculus, linear algebra, and vector calculus
- Familiarity with a graphics API (e.g. OpenGL)
  - If not, learn quickly (for the sake of visualization)
- C/C++ coding skills
  - If Java is preferred, you will be on your own
- Capability to search Google and forums for useful information ☺

Course Overview

Topics

- Shape representations in computer graphics
  - Points, implicits, meshes + related data structures
- Shape acquisition and reconstruction
- Linear algebra tools for geometric modeling
- Differential geometry (normals, curvatures, …)
- Digital geometry processing (smoothing etc.)
- Mesh deformation (space- and surface-based)
  - Approximately 40-50% of the course

Grading

- 30% - Assignments (can be done in teams)
  - Assignment 1: Mesh processing “Hello World”. mesh data structure programming + rendering
  - Assignment 2: Basic local mesh operations + selection tools
- 40% - Final project (can be done in teams)
  - Implementation/extension of a space or surface based editing tool (makes use of assignments 1+2)
  - Includes proposal, report and presentation

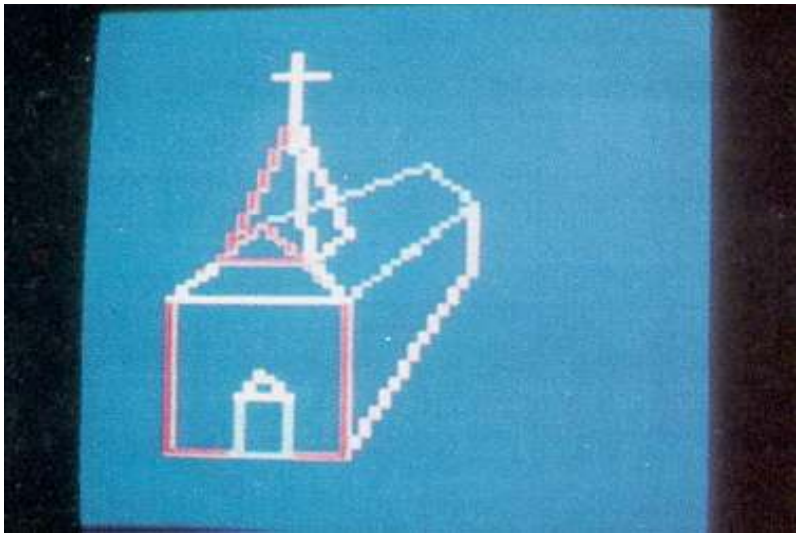
Grading

- 20% - Paper presentation (teams. depends on class size.)
  - Many possible sources: SIGGRAPH, Symposium on Geometry Processing (SGP), Shape Modeling International (SMI), Eurographics, see **`http://kesen.huang.googlepages.com/`**
  - 15-20 minute power point presentation + discussion with me (latest) one day before class
- 10% - Class participation
  - Feedback on peer paper presentation + application presentations, etc.

Computer Graphics

The big picture

- 3D graphics programming in 1979



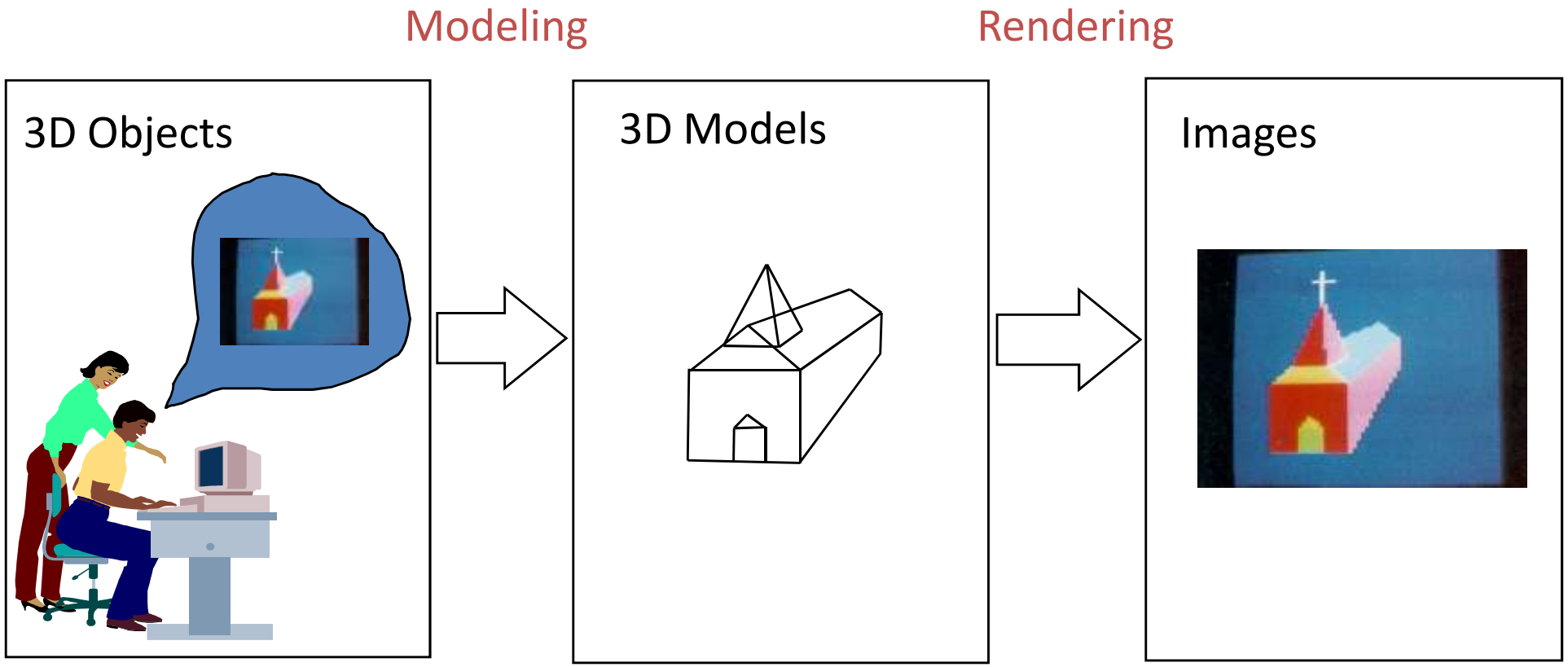
approx. 25 triangles

approx. 50 x 100 pixels

Computer Graphics

The big picture

- Common workflow



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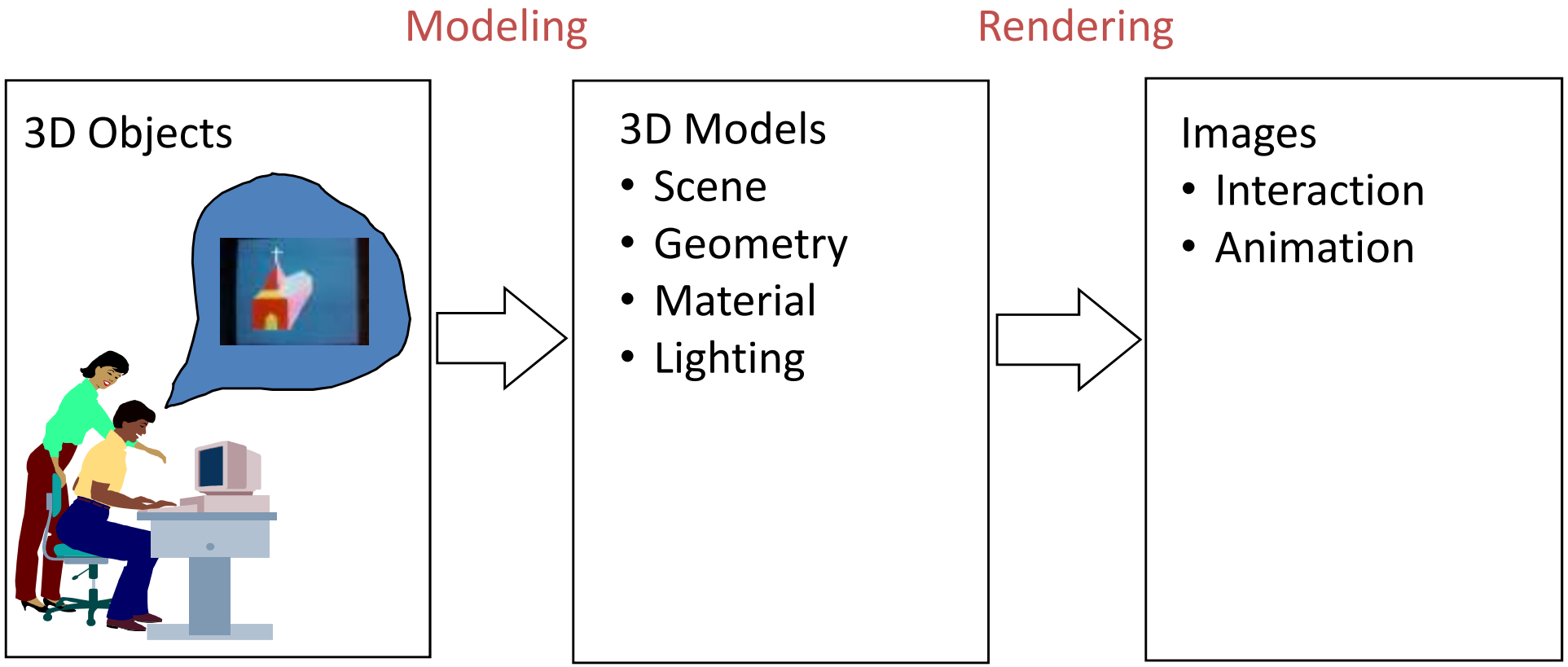
Computer Graphics

The big picture

- Common workflow



Computer Graphics

The big picture

- Common wo

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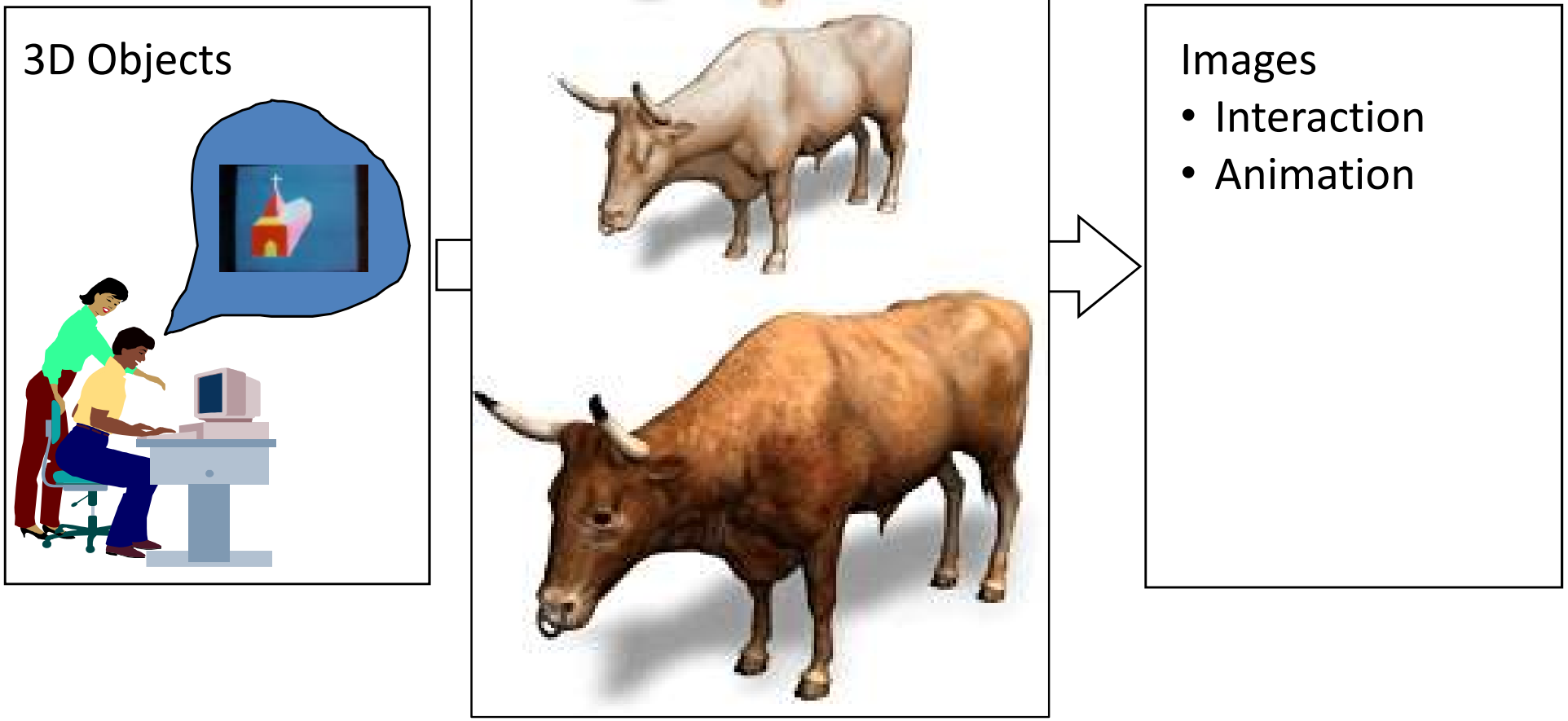
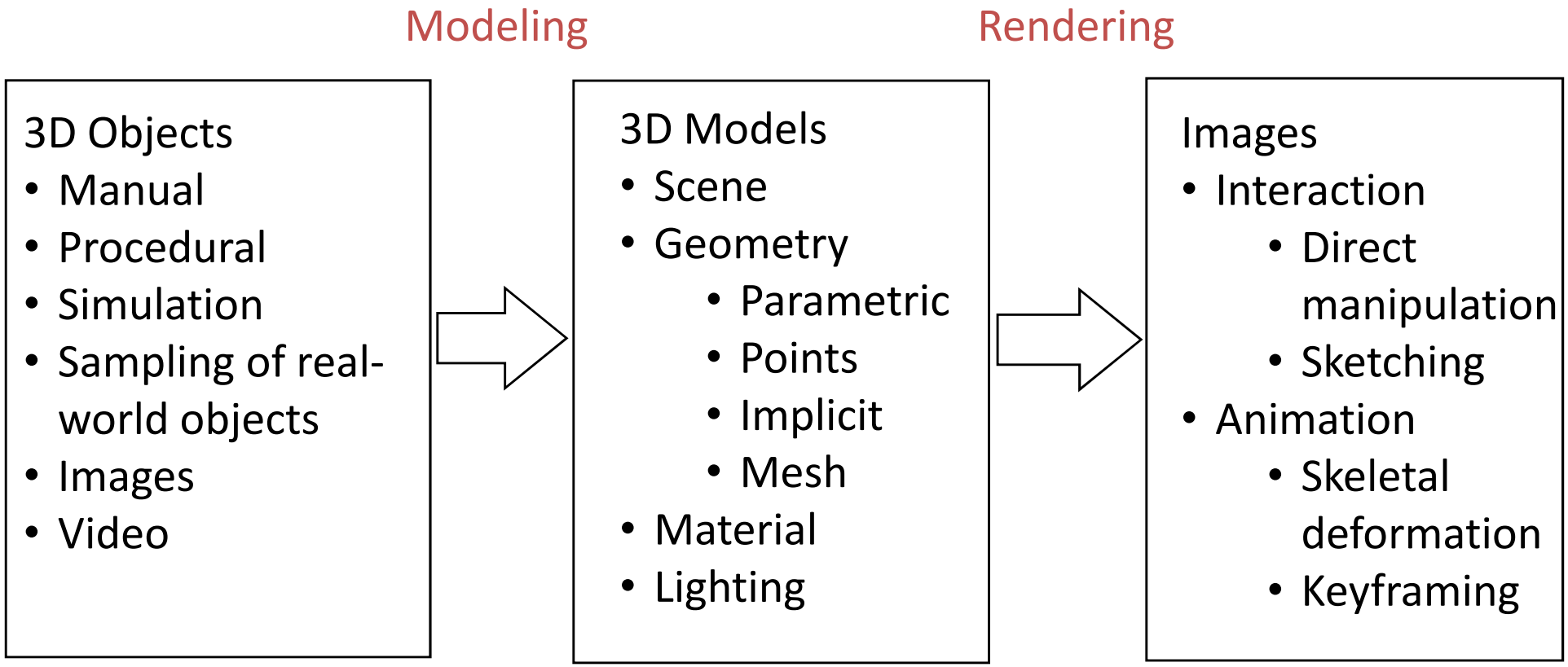


Computer Graphics

The big picture

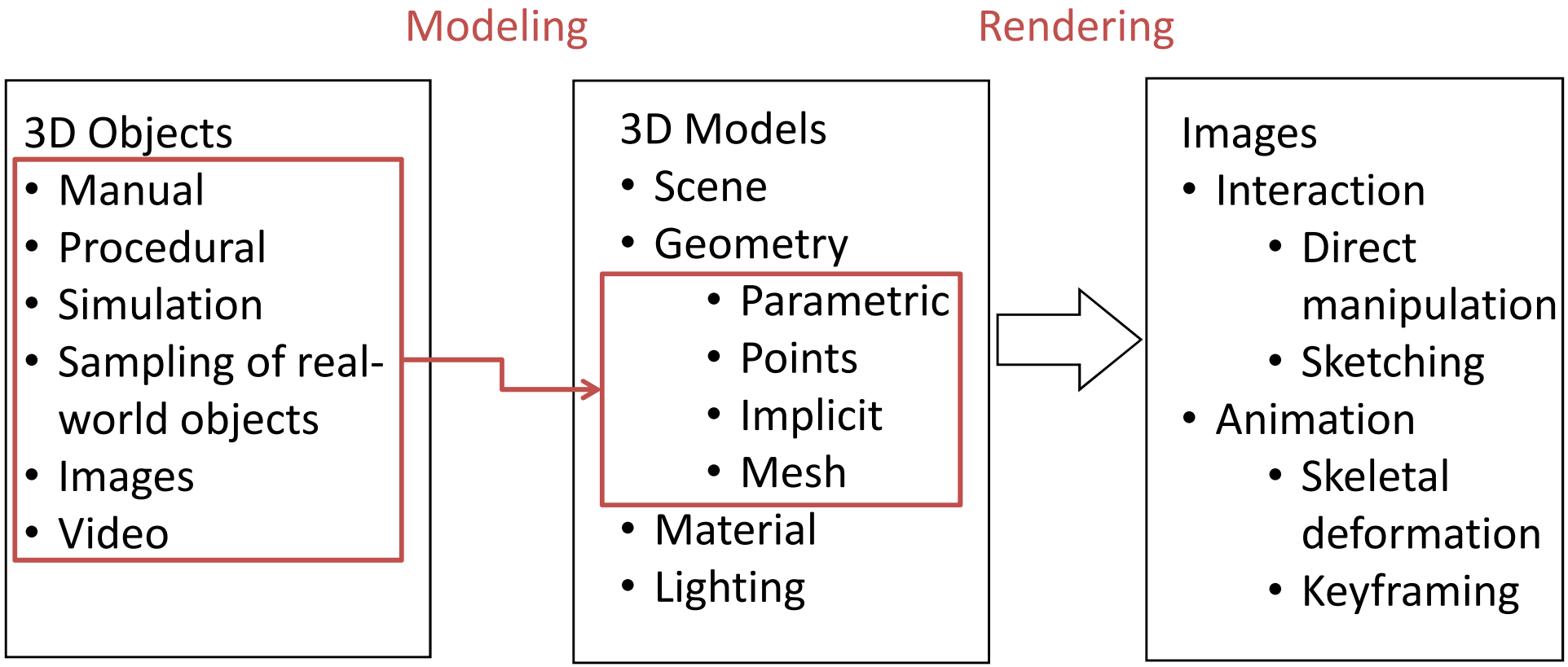
- Common workflow



Computer Graphics

The big picture

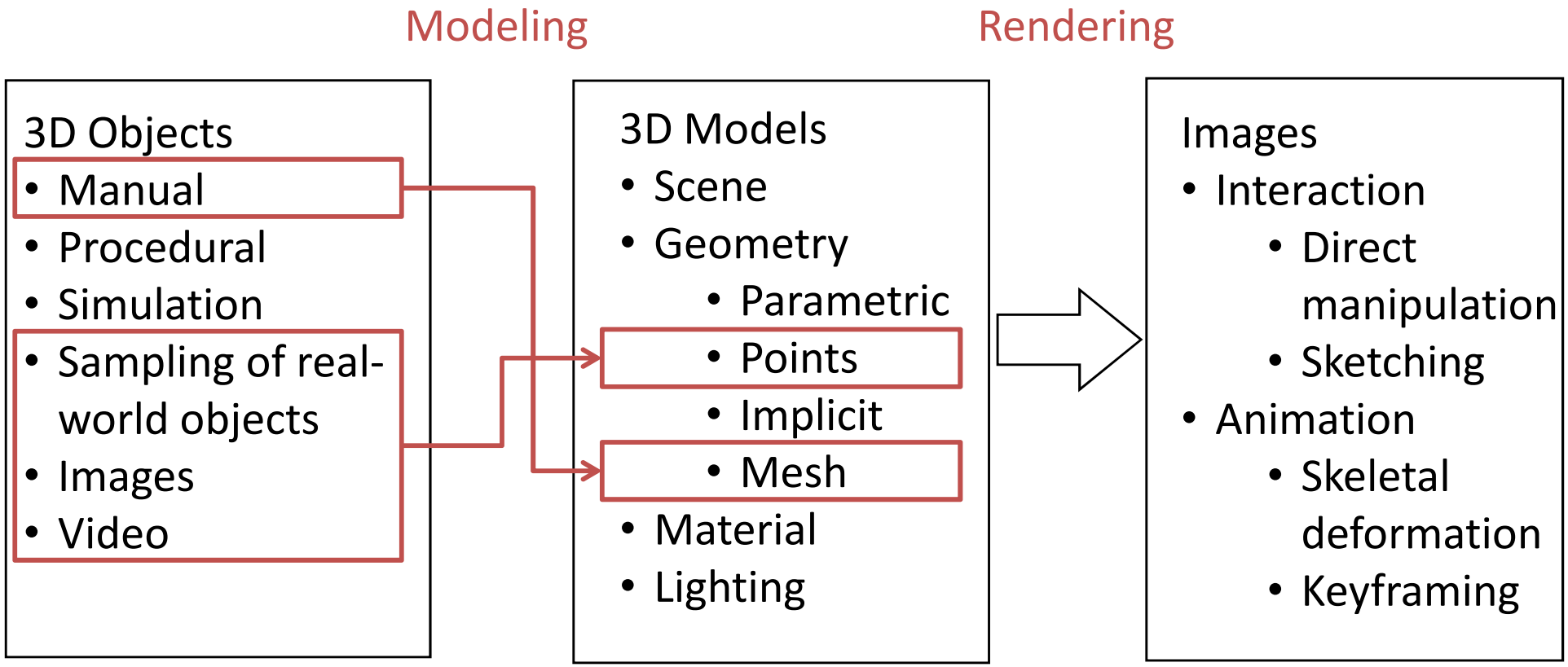
- Model creation



Computer Graphics

The big picture

- Model creation



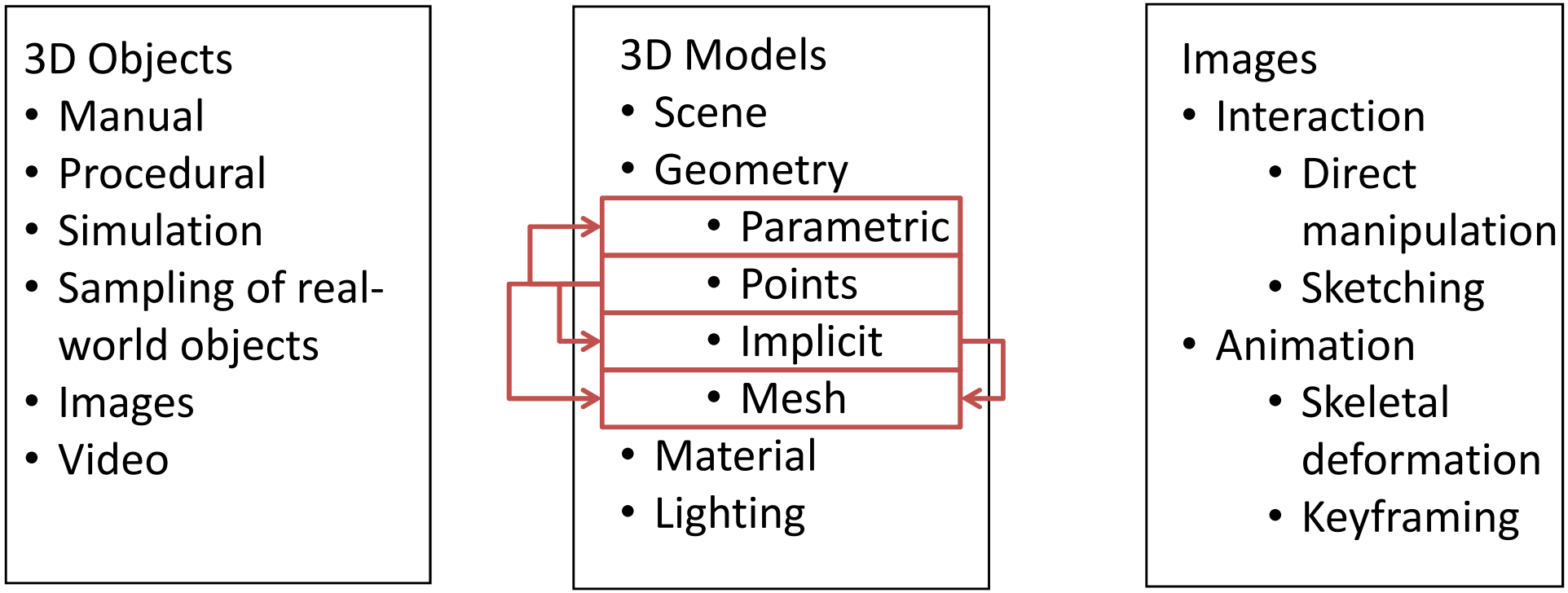
Computer Graphics

The big picture

- Model representation and conversion

Modeling

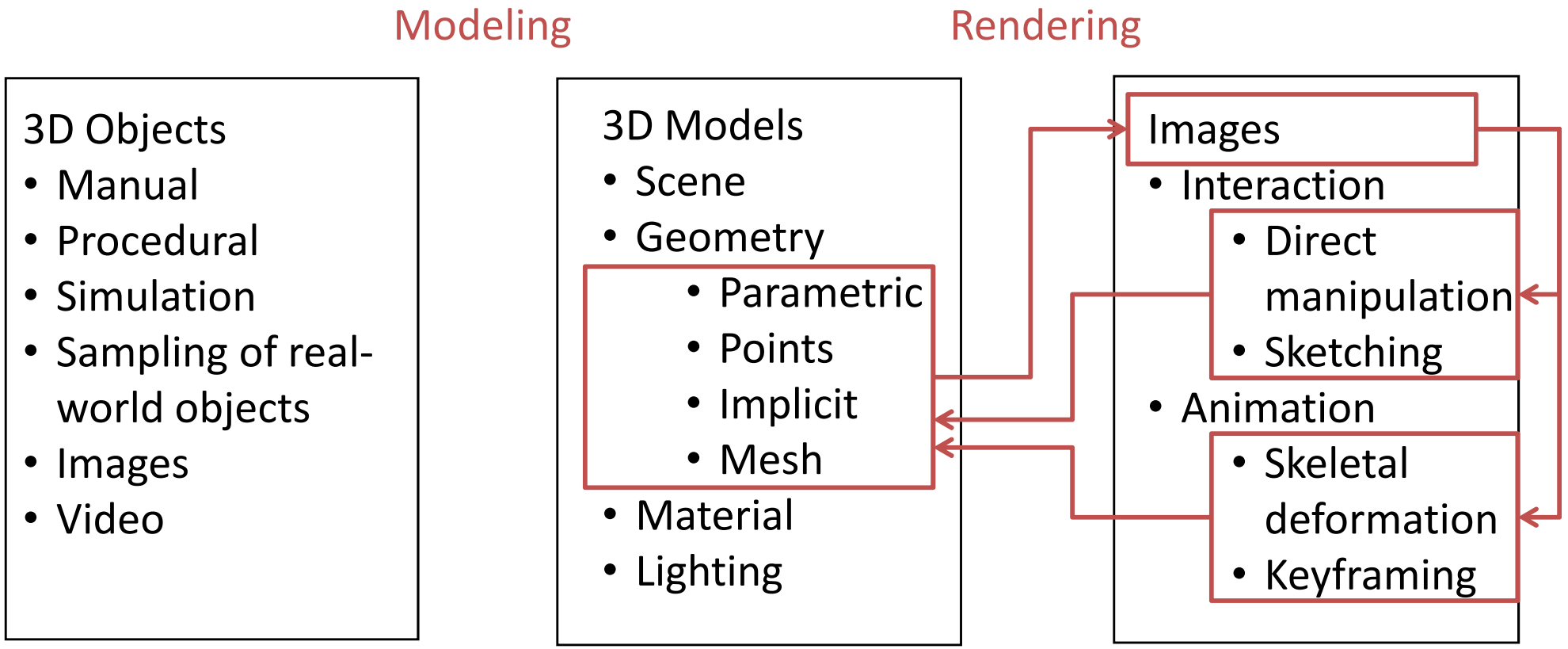
Rendering



Computer Graphics

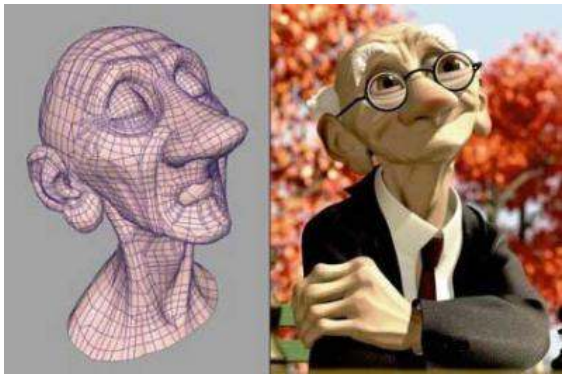
The big picture

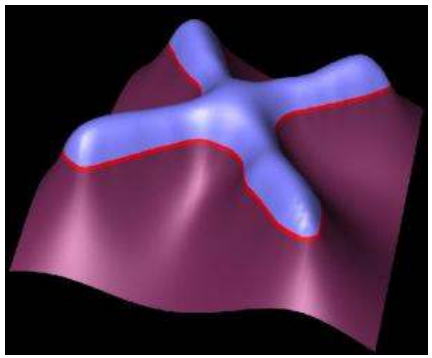
- Model modification and editing loop

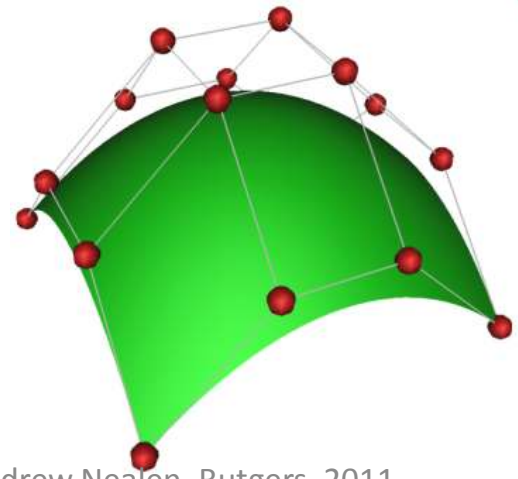


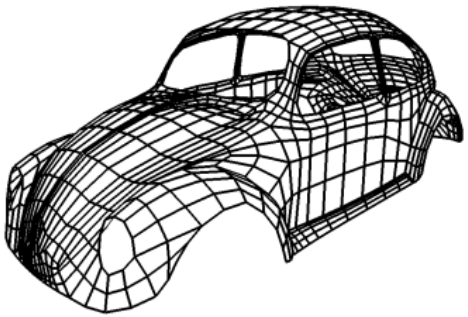
Course Topics

- Shape representation
  - Parametric surfaces
  - Subdivision surfaces
  - Implicits



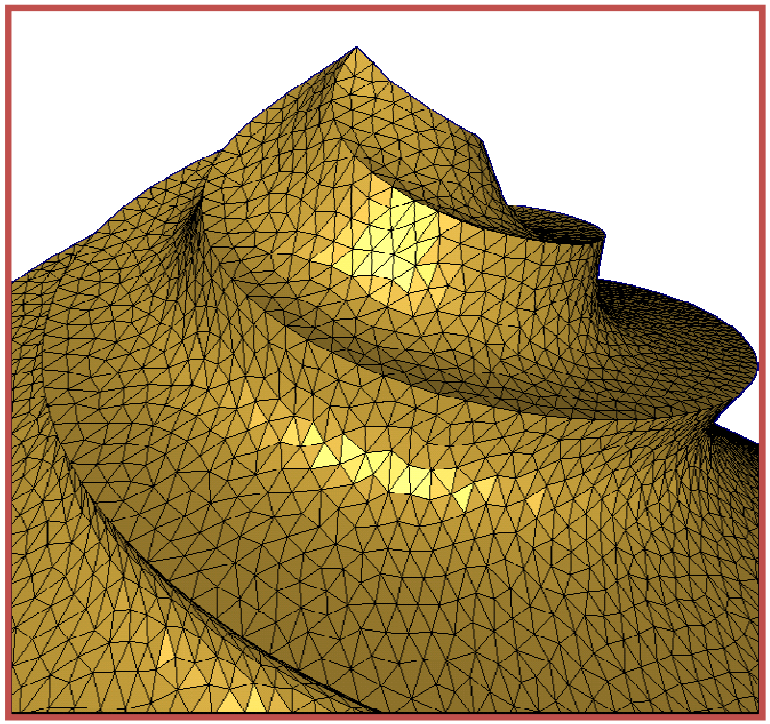


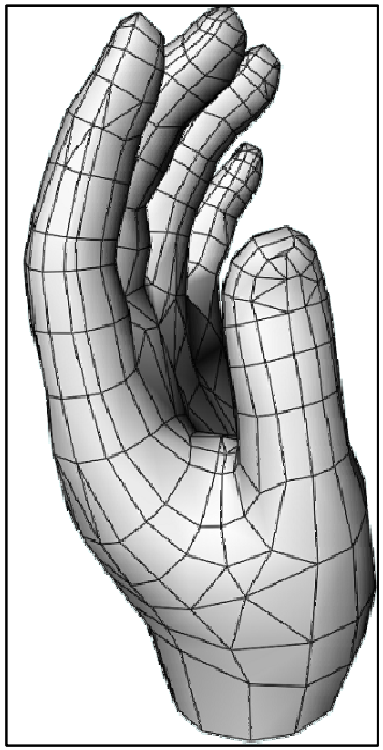


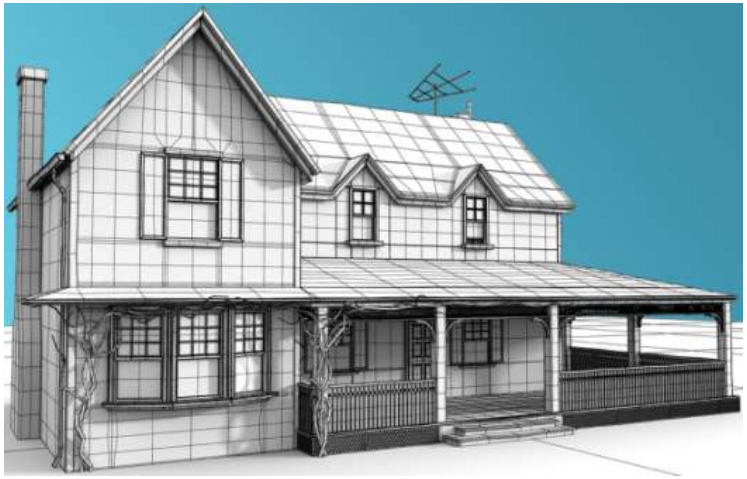


Course Topics

- Shape representation
  - Polygonal meshes

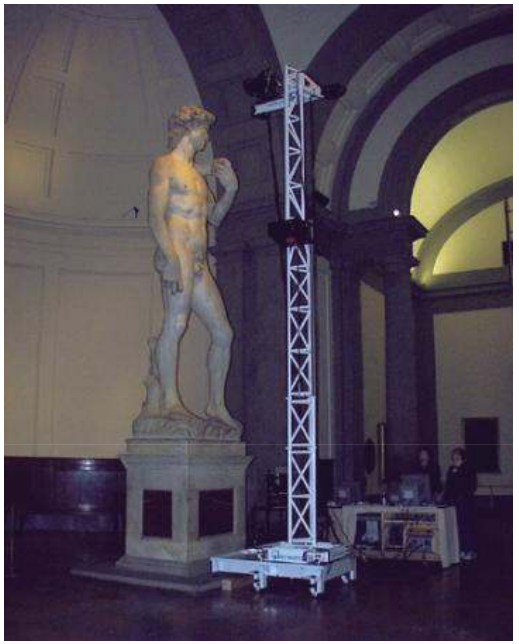


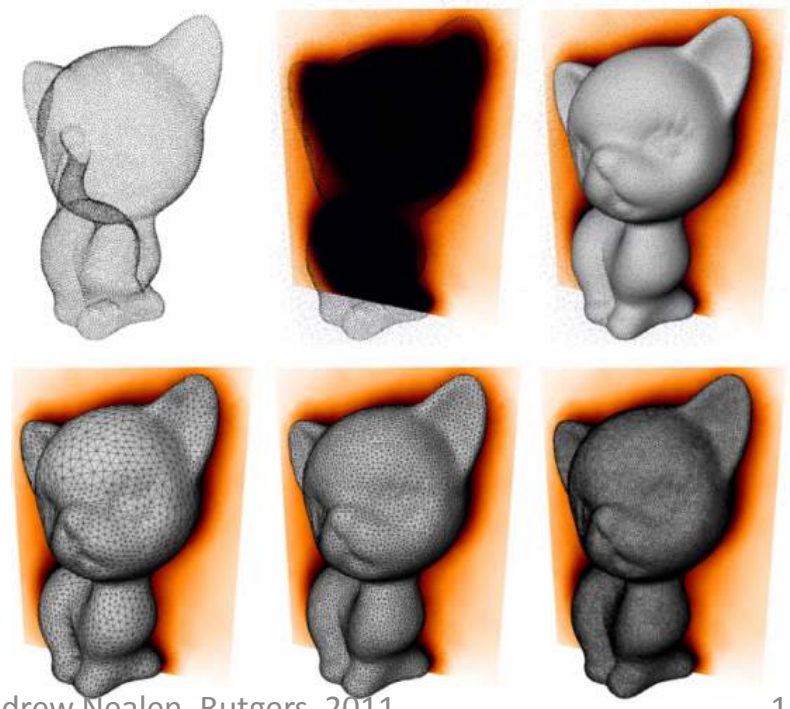


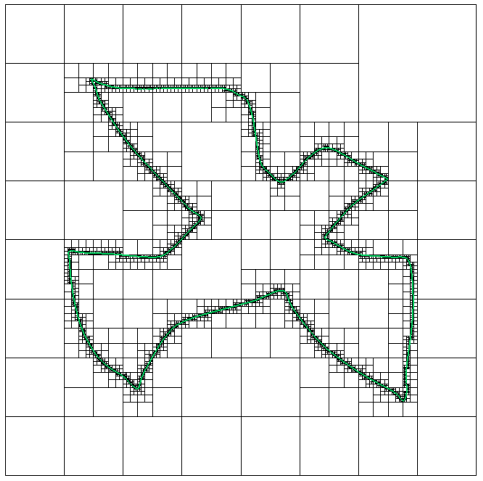


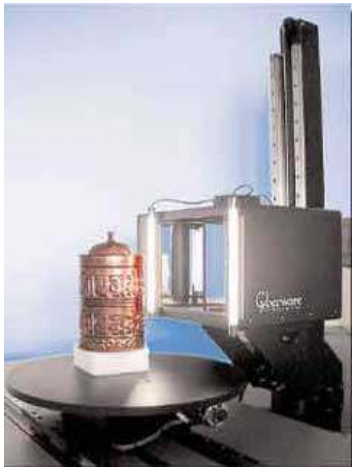
Course Topics

- Shape acquisition
  - Scanning/imaging
  - Reconstruction



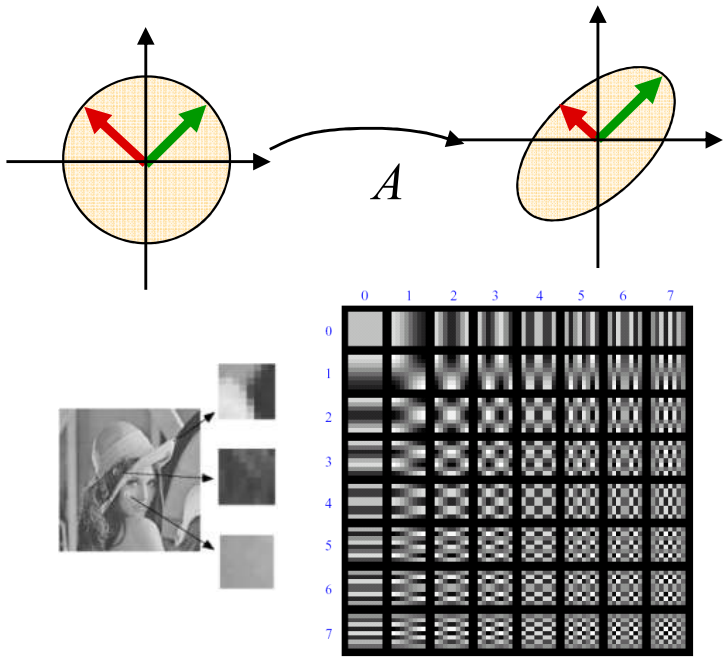


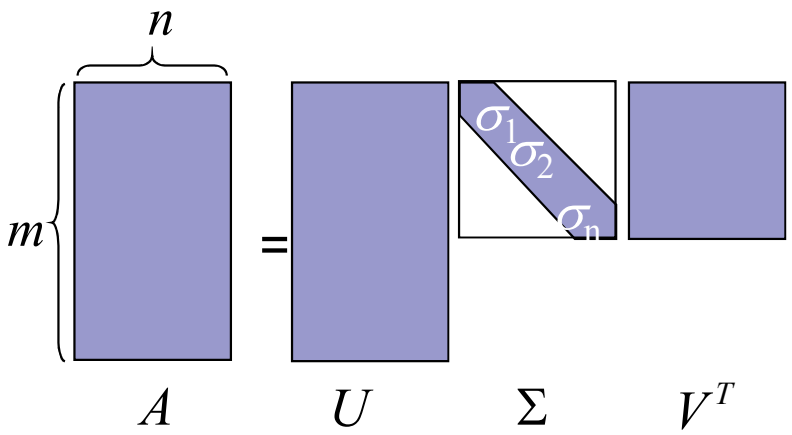




Course Topics

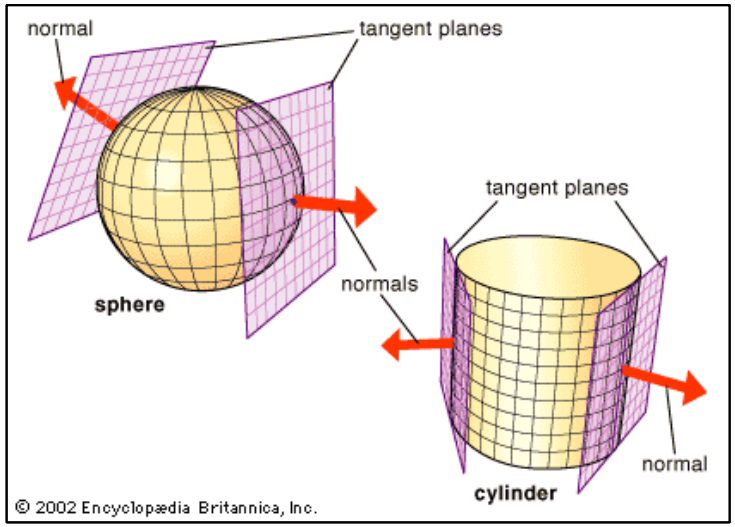
- Mathematical tools
  - Revisit linear algebra: transformations, spectral decomposition, PCA, SVD
  - See where these are used!

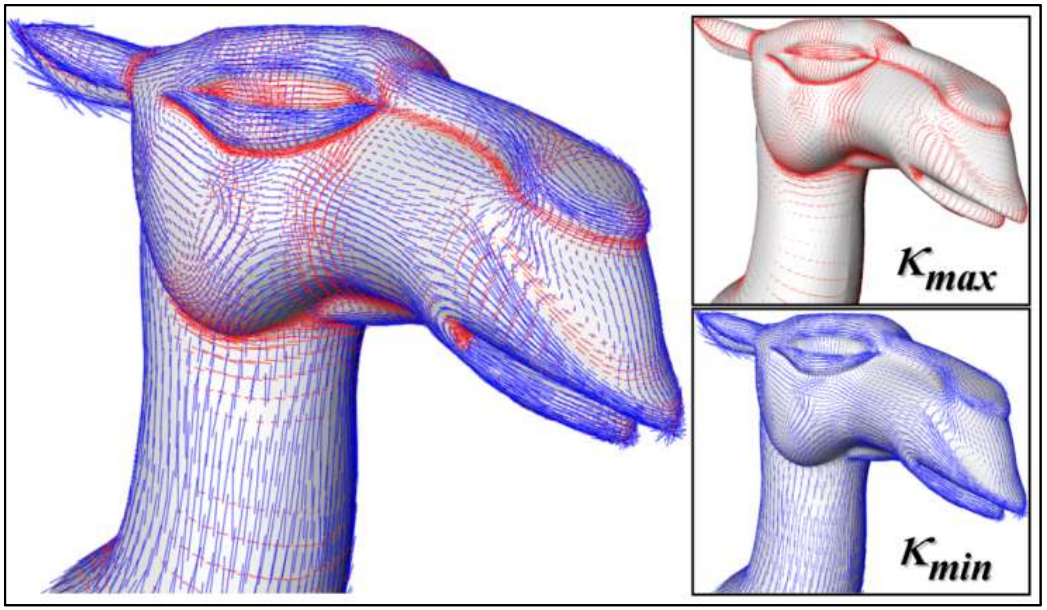




Course Topics

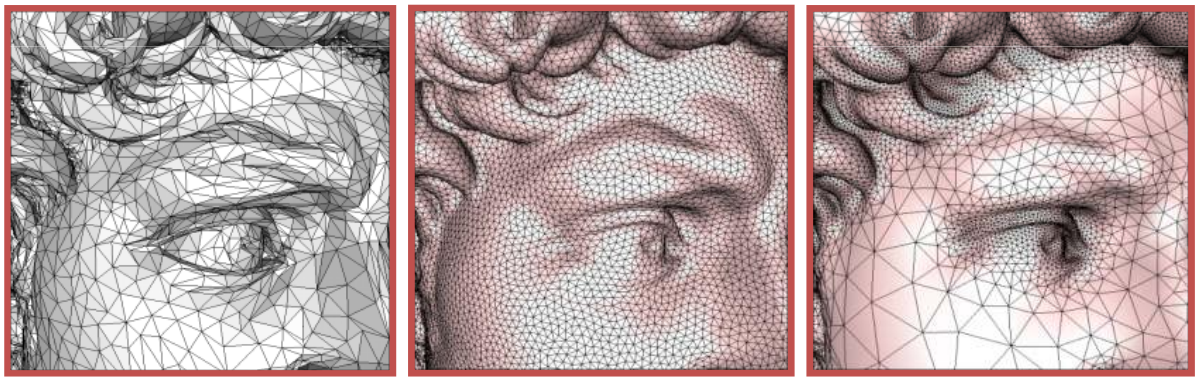
- Mathematical tools
  - Differential geometry – continuous and discrete
  - Our main tool to analyze and understand shapes

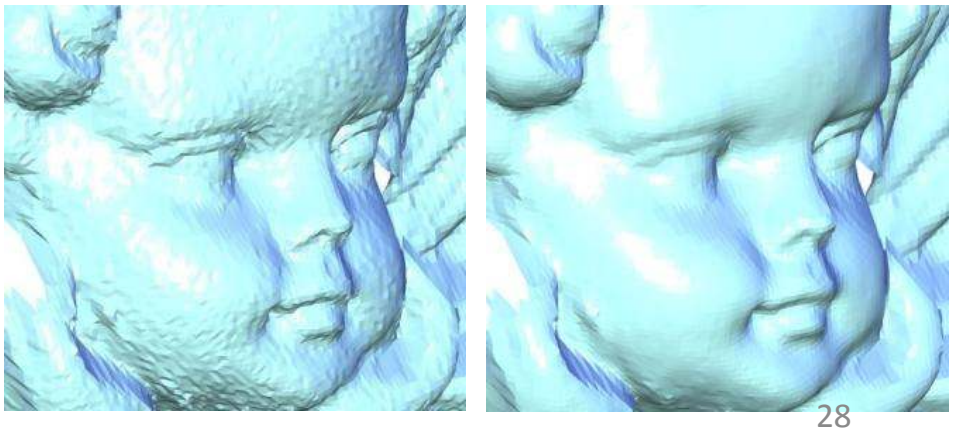




Course Topics

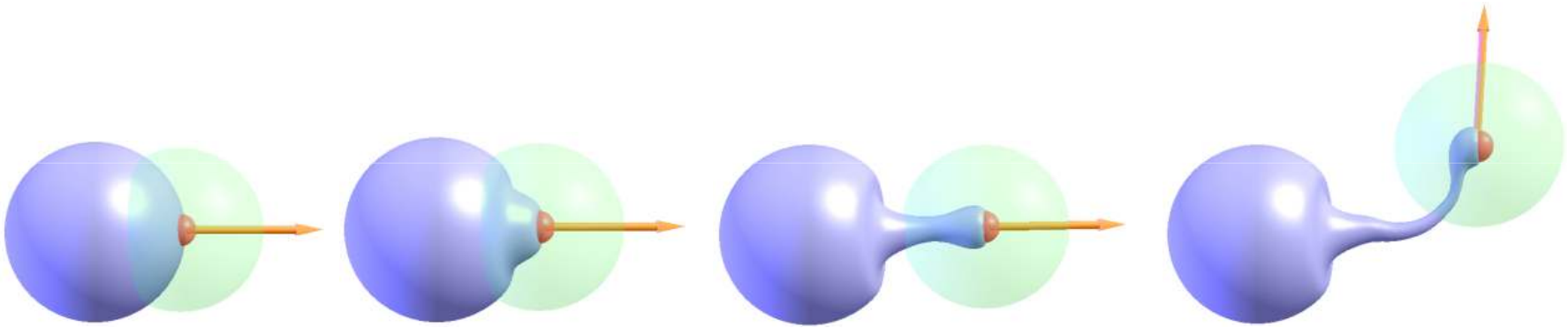
- Digital geometry processing
  - Denoising, smoothing, simplification/remeshing, parameterization, compression

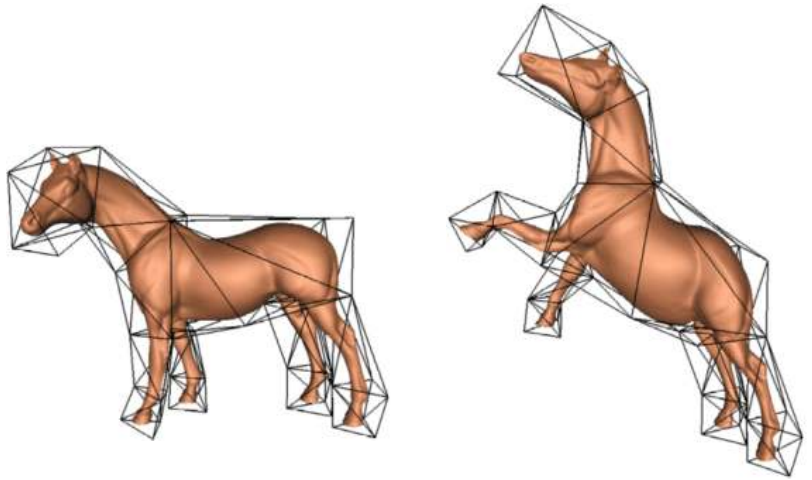


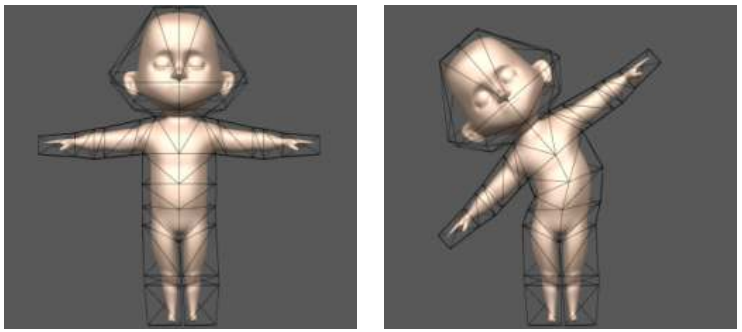


Course Topics

- Shape modeling and deformation
  - Space warps/ Freeform deformations

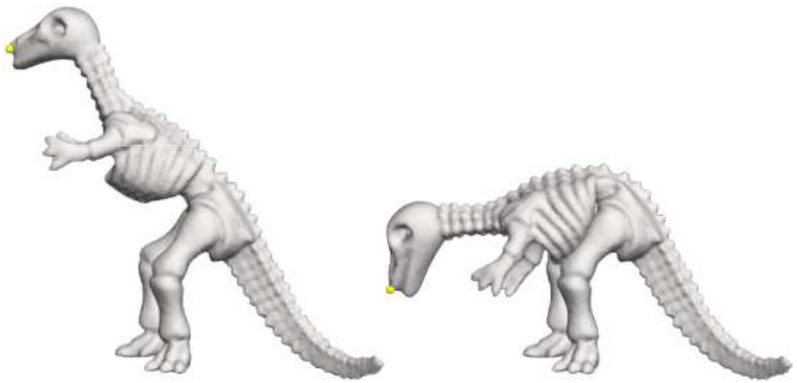


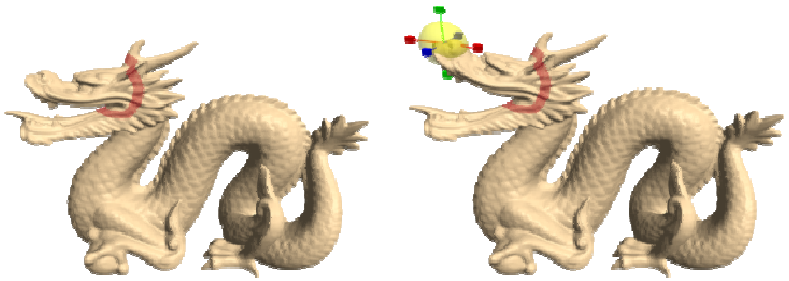


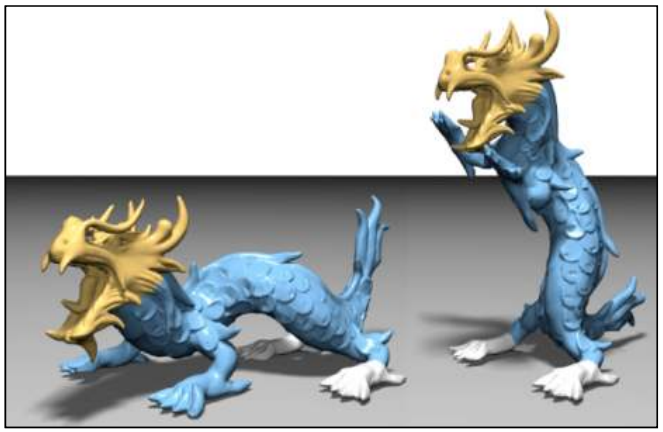


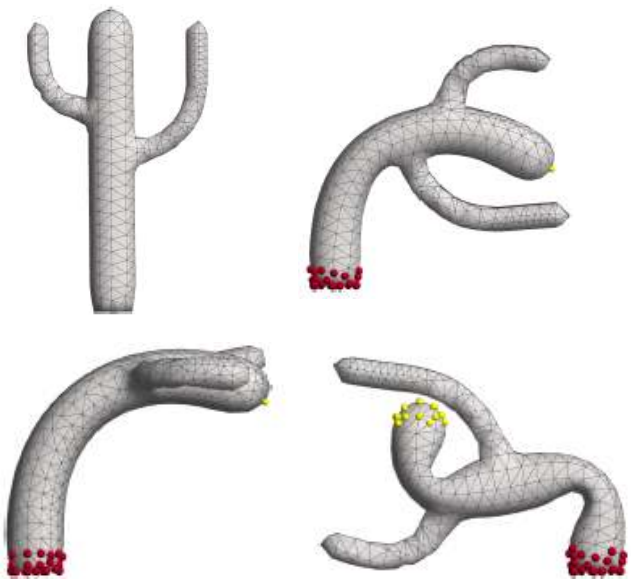
Course Topics

- Shape modeling and deformation
  - Surface-based deformations



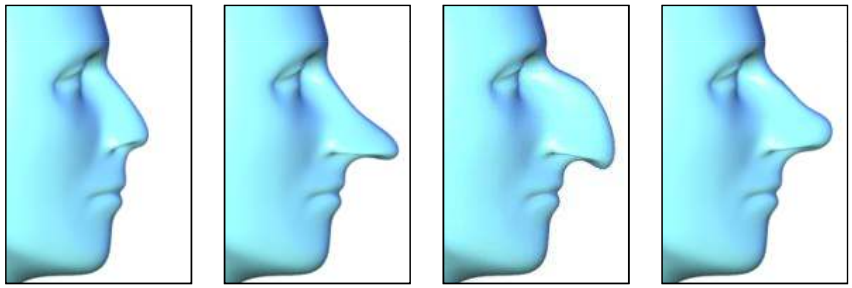


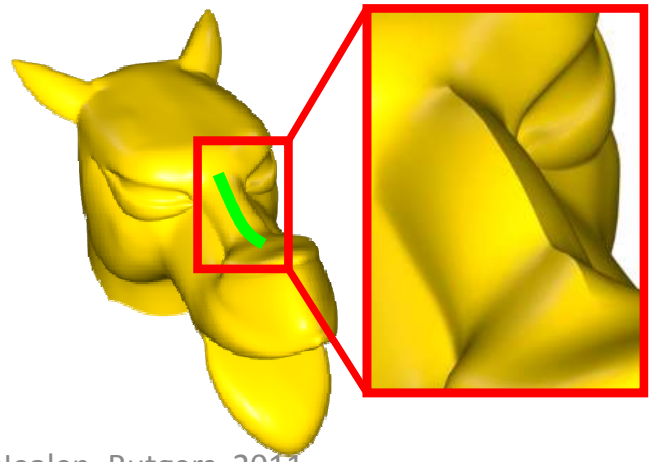


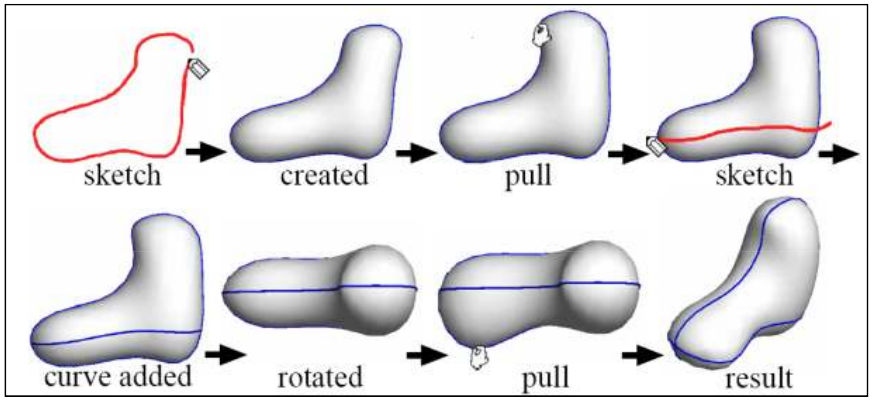


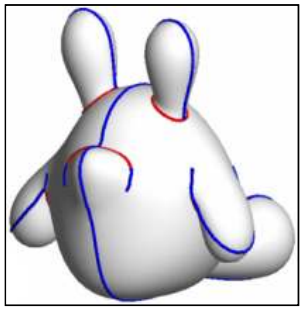
Course Topics

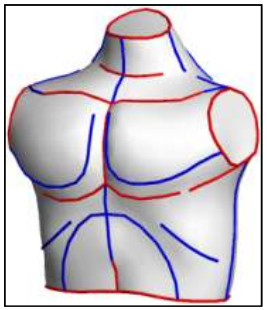
- Sketch-based interfaces
  - Shape creation
  - Shape editing

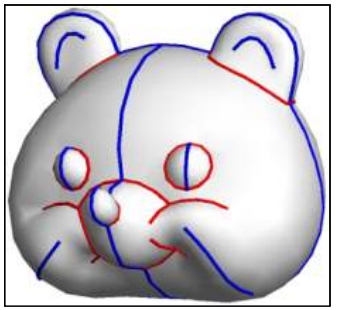






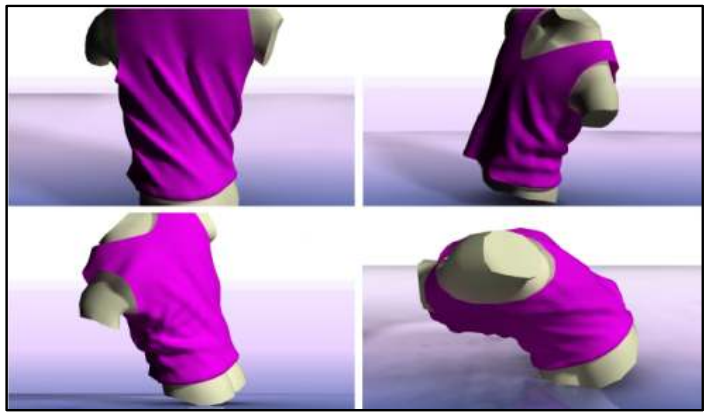


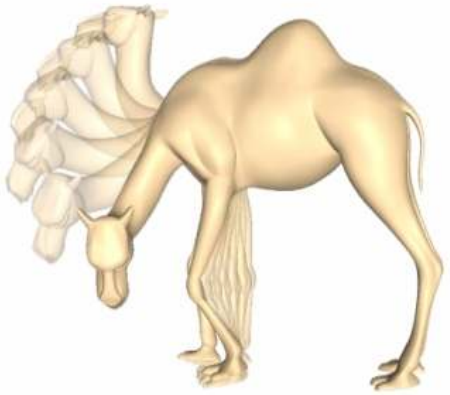




Course Topics

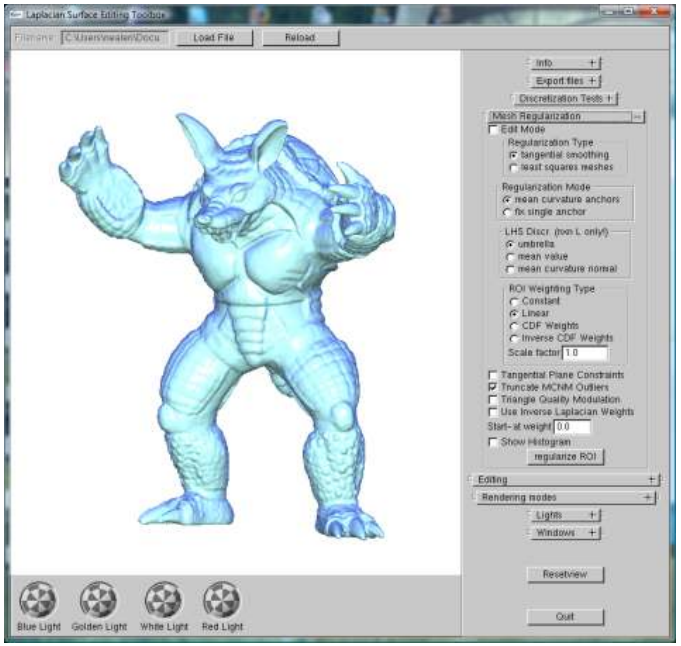
- More applications of geometric deformation
  - Skeleton-skin animation; morphing
  - Image/video retargeting





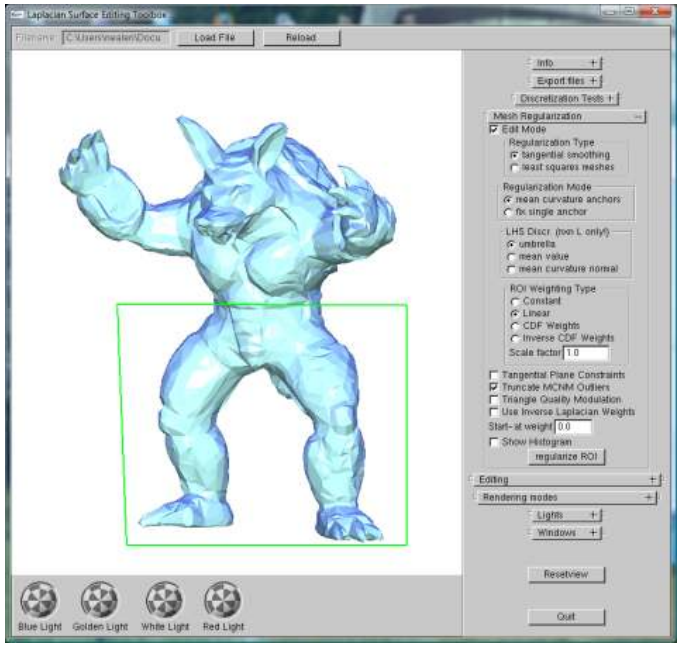
Assignments

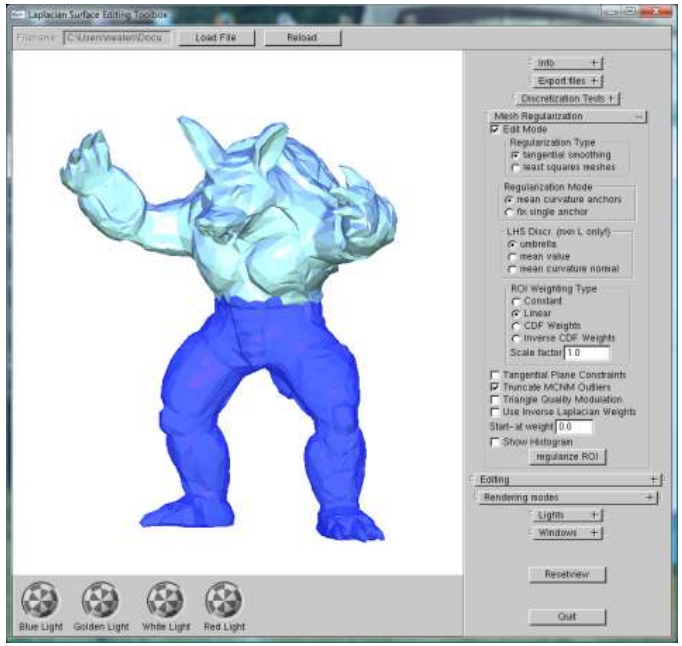
- Assignment 1: Mesh processing “Hello World”
  - Goals: learn basic mesh data structure programming + rendering (flat/gouraud shaded, wireframe) + basic GUI programming

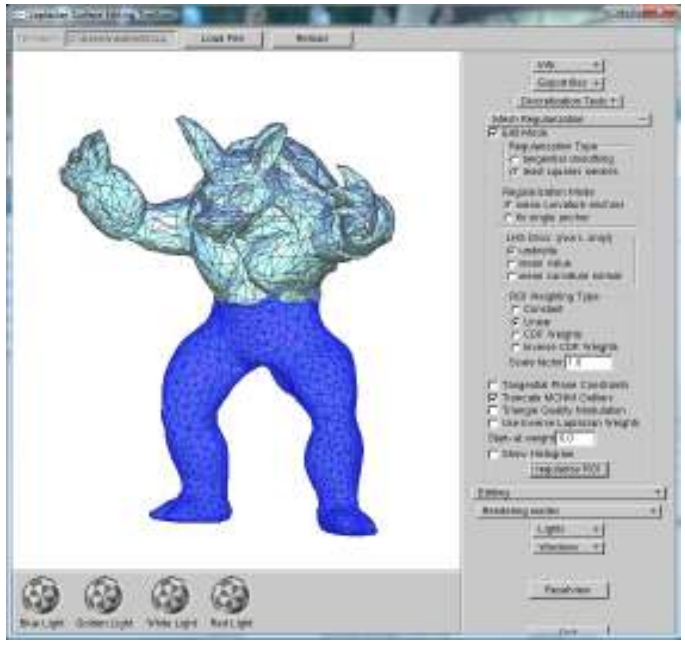


Assignments

- Assignment 2: selection + operation tools
  - Goals: implement image-space selection tools and perform local operations (smoothing, etc.) on selected region

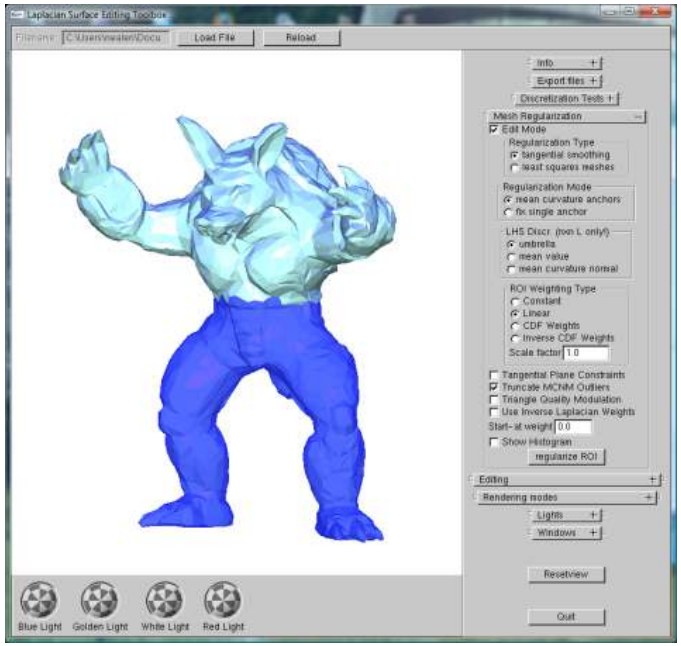


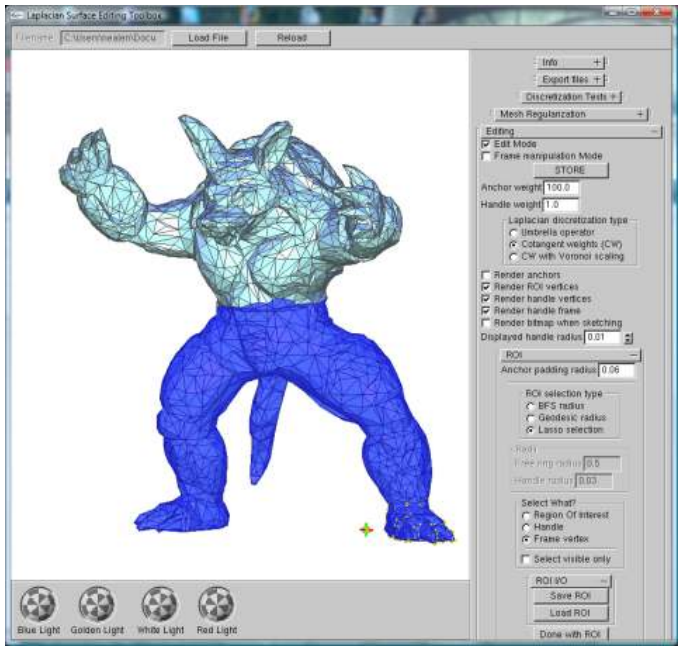




Final Project

- Implementation/extension of a space or surface based editing tool
  - makes use of assignments 1 + 2
  - Your own suggestion, with instructor approval





Final Project

- Includes written project report and presentation
  - Latex style files will be provided
  - Power Point examples will be provided