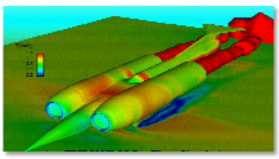
G22.3033-004, Spring 2009

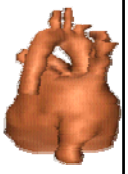
Interactive Shape Modeling

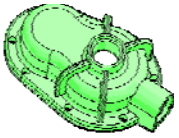
Introduction and Overview

Geometric Modeling

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

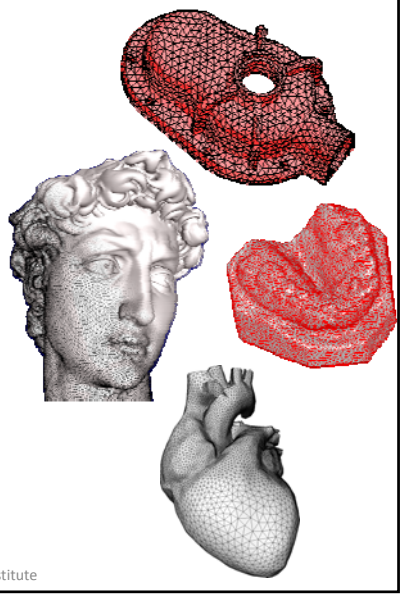






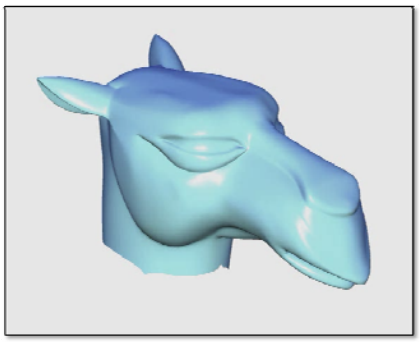
Digital Geometry Processing (DGP)

- 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



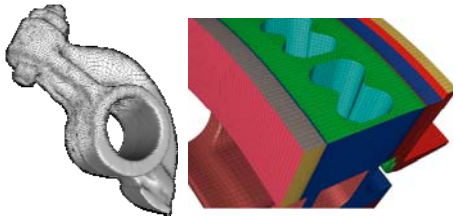
Interactive shape modeling

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

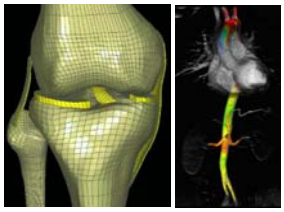


Applications

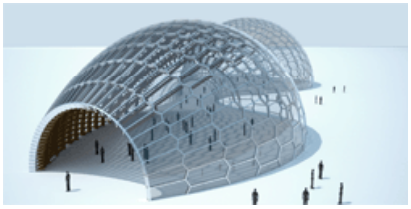
Games/Movies



Engineering



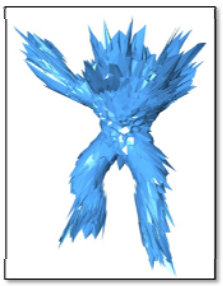
Medicine/Biology



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, 7-8pm, Room 1204
  or other time (coordinate via e-mail)

Organization

- Course website
  http://www.cs.nyu.edu/courses/spring09/G22.3033-004/index.html
- Mailing list: g22_3033_004_sp09@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 (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

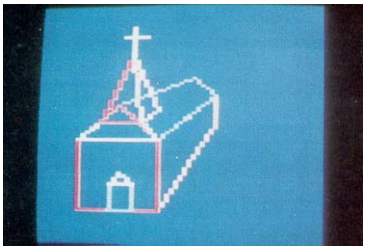
Grading

- 40% - Assignments
  - Assignment 1: Mesh processing “Hello World”. mesh data structure programming + rendering
  - Assignment 2: Basic local mesh operations + selection tools
- 60% - Final project
  - Implementation/extension of a space or surface based editing tool (makes use of assignments 1+2)
  - Your own suggestion, with instructor approval
  - Includes: proposal, report and presentation

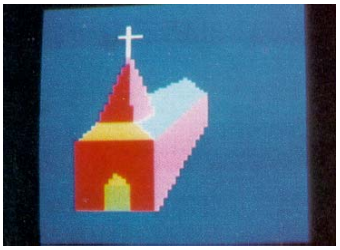
Computer Graphics

The big picture

- 3D graphics programming in 1979



approx. 25 triangles

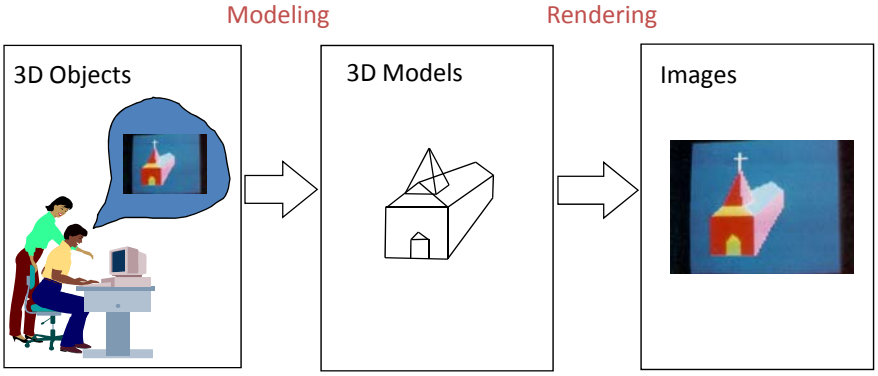


approx. 50 x 100 pixels

Computer Graphics

The big picture

- Common workflow



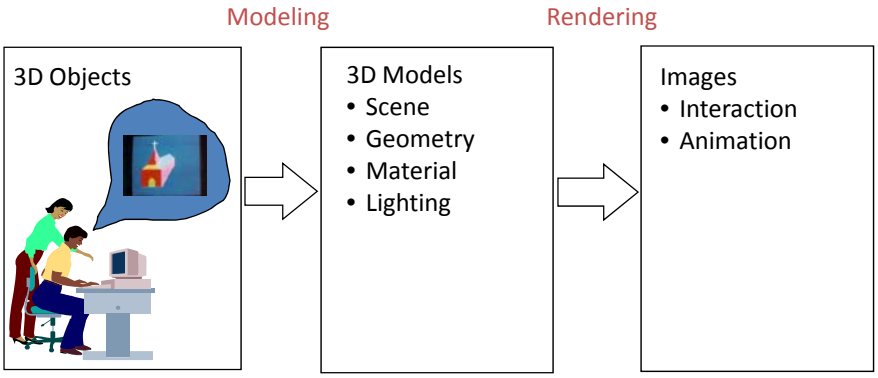
approx. 25 polygons

approx. 50 x 100 pixels

Computer Graphics

The big picture

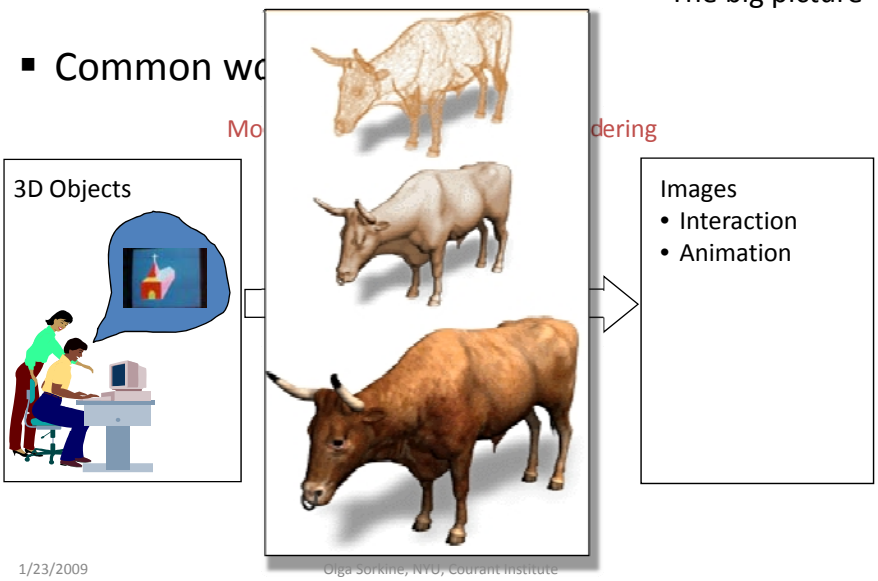
- Common workflow



Computer Graphics

The big picture

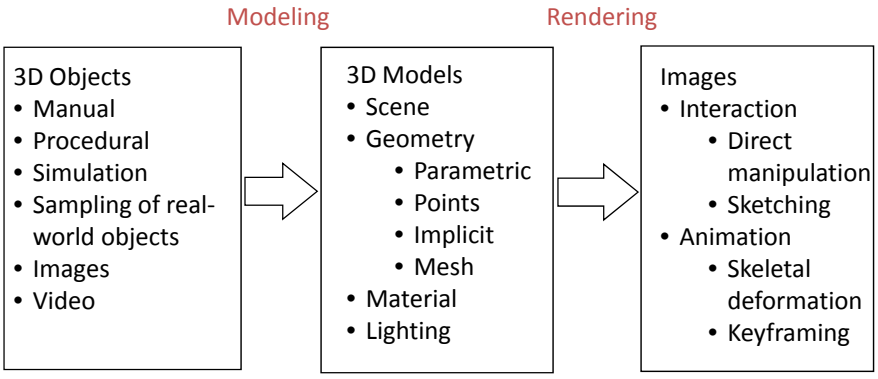
- Common wo



Computer Graphics

The big picture

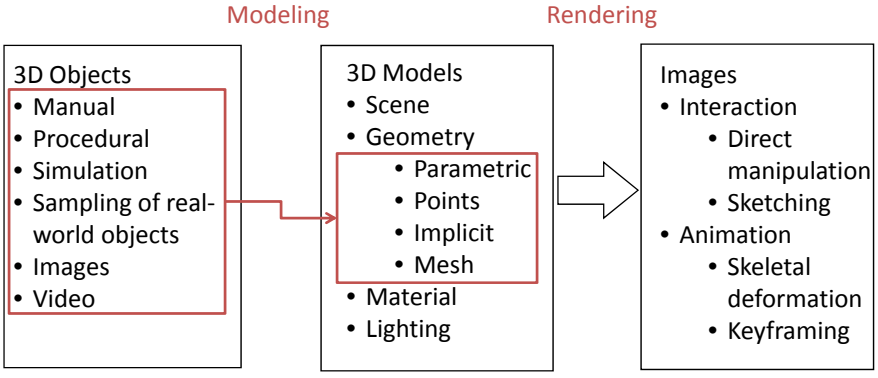
- Common workflow



Computer Graphics

The big picture

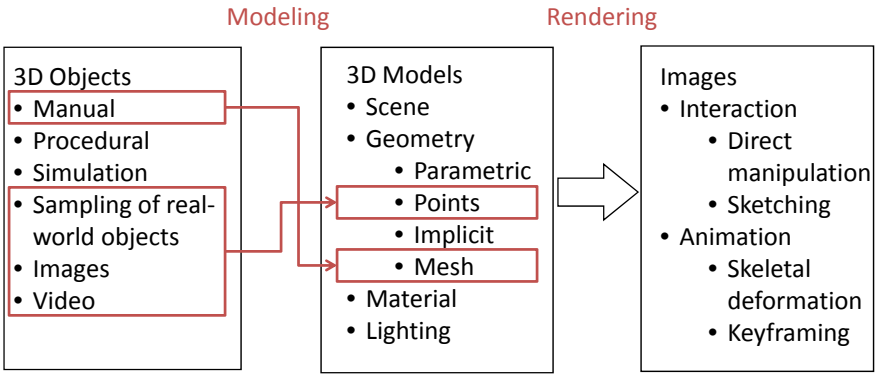
- Model creation



Computer Graphics

The big picture

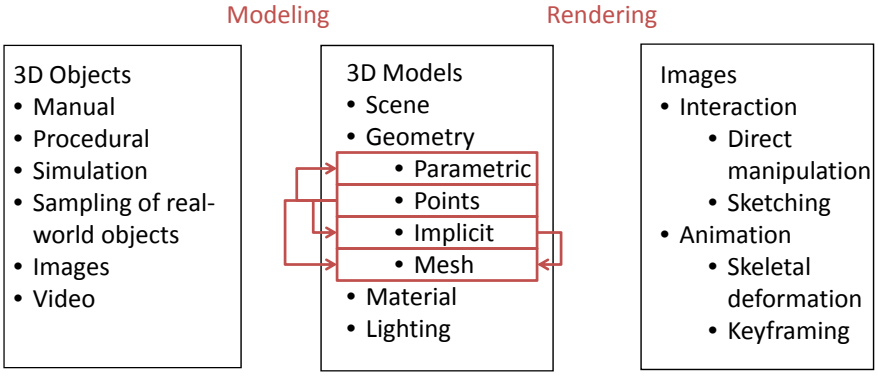
- Model creation



Computer Graphics

The big picture

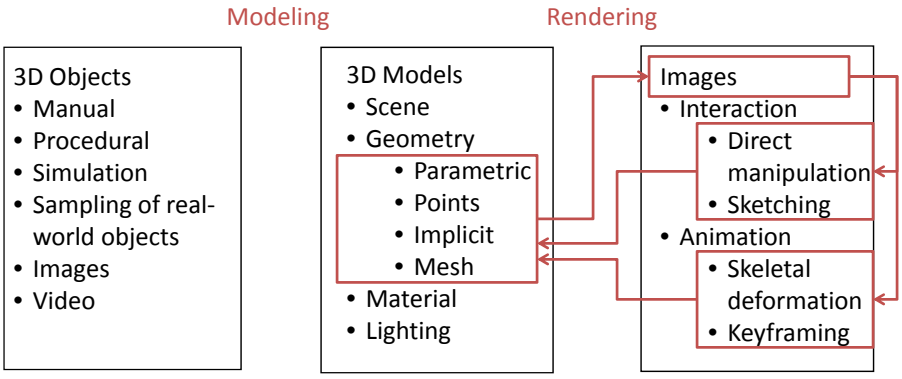
- Model representation and conversion



Computer Graphics

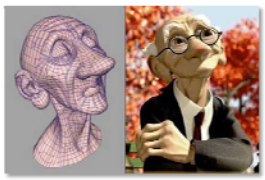
The big picture

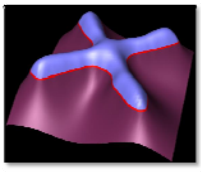
- Model modification and editing loop

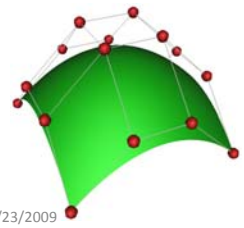


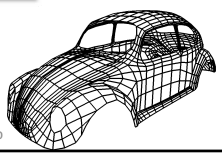
Course Topics

- Shape representation
  - Parametric surfaces
  - Subdivision surfaces
  - Implicits



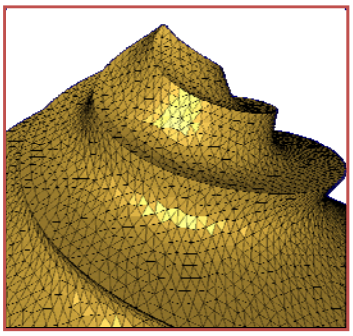
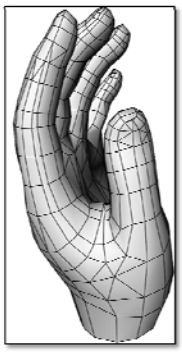
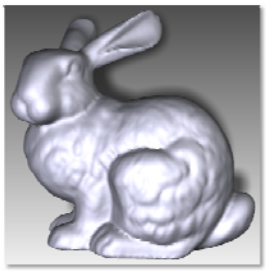
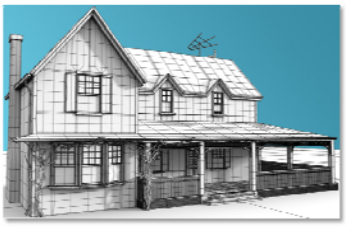






Course Topics

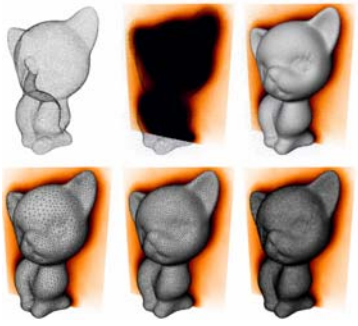
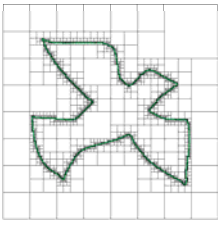
- Shape representation
  - Polygonal meshes

Course Topics

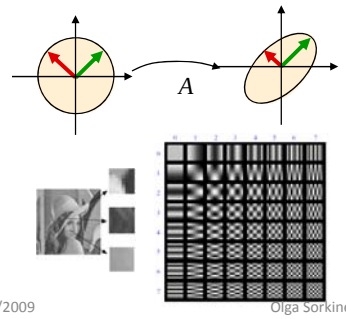
- Shape acquisition
  - Scanning/imaging
  - Reconstruction

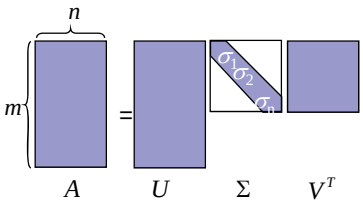



Course Topics

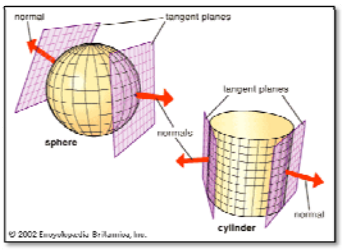
- Mathematical tools
  - Revisit linear algebra: transformations, spectral decomposition, PCA, SVD
  - See where these are used!

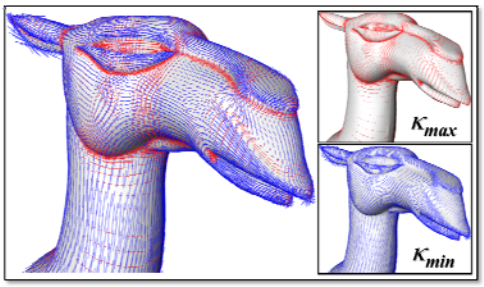




Course Topics

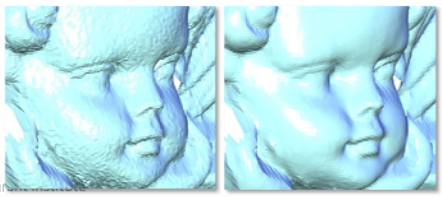
- Mathematical tools
  - Differential geometry – continuous and discrete
  - Our main tool to analyze and understand shapes





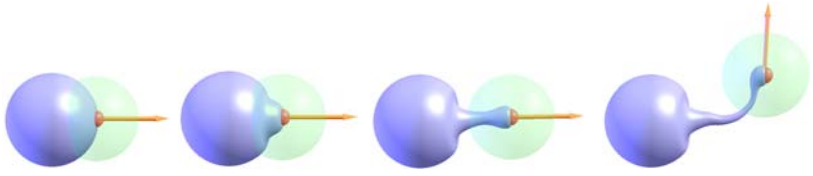
Course Topics

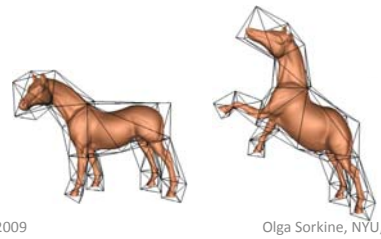
- Digital geometry processing
  - Denoising, smoothing, simplification/remeshing, parameterization, compression

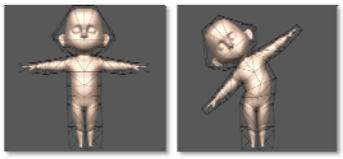


Course Topics

- Shape modeling and deformation
  - Space warps/ Freeform deformations

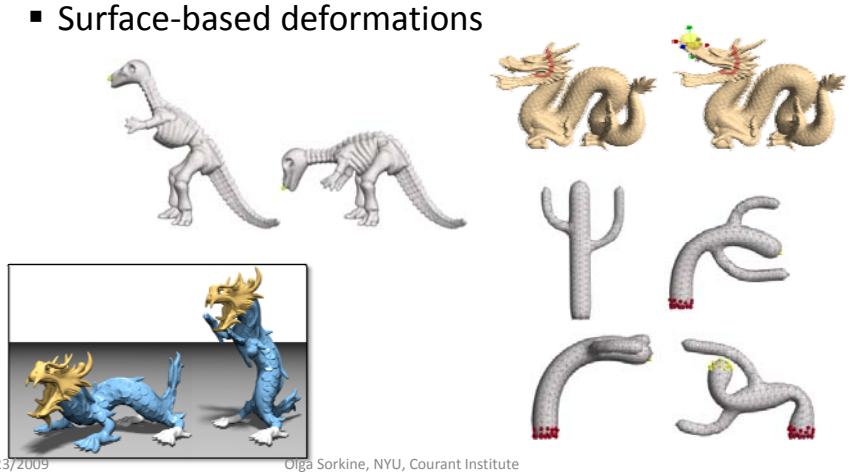






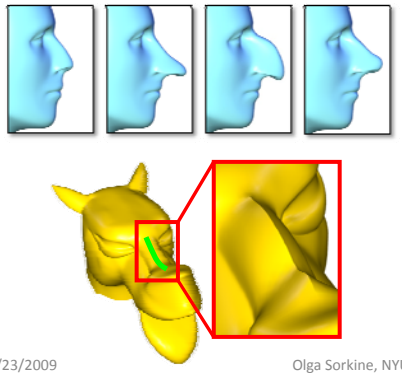
Course Topics

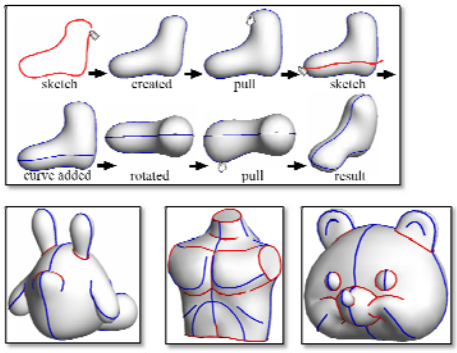
- Shape modeling and deformation
  - Surface-based deformations



Course Topics

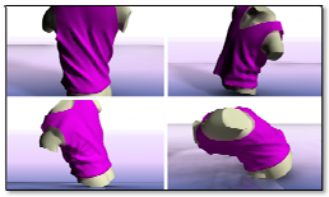
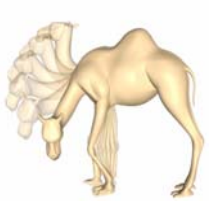
- Sketch-based interfaces
  - Shape creation
  - Shape editing





Course Topics

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

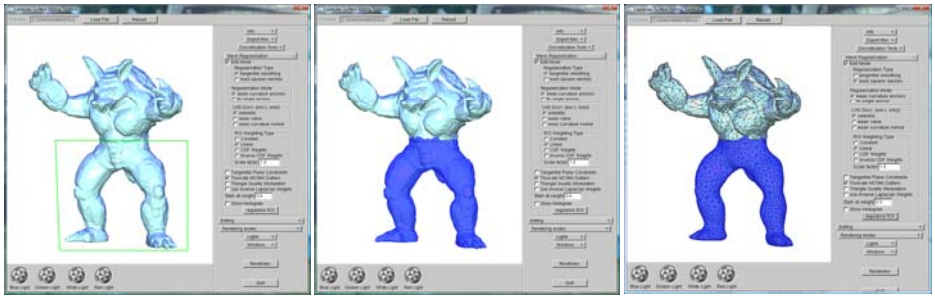




Assignments

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

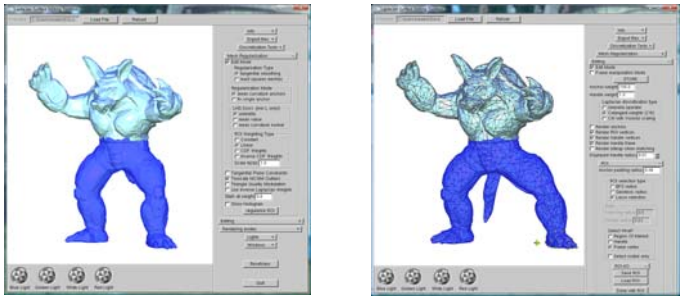

Assignments

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



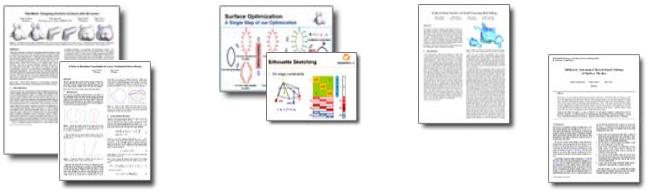
Final Project

- 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



Thanks

(and please register if you want to take the course)

Credits and Thanks: Alla Sheffer, Andrew Nealen, Scott Schaefer