Advanced Geometry
Topics

1. Automatic content creation

2. Level-of-detail representations

[Liu et al. Eurographics 2015]
Content creation
Traditional manual approach

- Use of 3D modeling software
- Manually define geometry and materials
- Compose model of multiple primitives
- Requires expertise and time, expensive

Example image of modeled fish from Wikipedia.
Automatic content creation

Main idea

• Generate 3D models without manual modeling

• Two options

  1. Measuring real-world objects

  2. Modifying existing 3D models
Measuring real-world objects
Traditional Acquisition Techniques

- Small set of discrete measurements
- Used in different applications
  - Anthropometric measurements
  - Surveying
- Main advantage
  - Easy to acquire and process measurements
- Main disadvantage
  - Impossible to get a detailed shape description
3D Scanners

• New technology
  • 3D (animation) scanners
  • Record 3D video
  • Active research area

• Powerful tool
  • Preserve artwork / historic artifacts
  • Acquire populations of 3D shapes for analysis

[P. Jenke, WSI/GRIS Tübingen]
Types of 3D Scanners

Scanning Techniques:

- **Time-of-flight**
  - Time-of-flight laser scanner
  - Time-of-flight depth cameras (dynamic)

- **Triangulation**
  - Laser line sweep
  - Structured light

- **Stereo / computer vision**
  - Passive stereo
  - Active stereo / space time stereo
  - Other techniques
Example Scan (time of flight laser scanner)
Example scan (structured light scanner)

color-coded structured light
courtesy of Phil Fong, Stanford University

motion compensated structured light
courtesy of Sören König, TU Dresden
Example scan (active stereo scanner)
Example scan (stereo reconstruction)

**multi view matching (8 cameras)**
(piecewise smooth variational surface on presegmented images solved with Bayesian belief propagation)

[Data set: Zitnick et al., Microsoft Research, Siggraph 2004]

**multi view matching (6 cameras)**
(photo-consistent space carving)

[Data set: Christian Theobald, MPII, 2006]
Processing the scans

To be useful, the scans need to be processed

- Hole filling
- Outlier removal
- ...

- Many methods and software libraries available
Allows for direct content creation
Modifying existing 3D models
Possibilities

• Common possibilities
  - Extrapolation
  - Interpolation
  - Structure-aware modification

• Many possibilities, active area of research
Exercise

Propose a way to interpolate and extrapolate between two 3D shapes

• How do you represent the shapes?
• What interpolation / extrapolation equation to use?
• What are the advantages and disadvantages of the method?
Shape interpolation and extrapolation

• Possible in shape space using correspondence information
Statistical shape spaces possible

- Learn statistical distribution of geometry of shape

- Use this information for synthesis
Structure-aware modification

Challenge
  - Direct point-to-point correspondence cannot be established
  - Point-wise or triangle-wise modification not meaningful

Liu et al. Eurographics 2015
  - Active area of research
Take advantage of symmetry information

Kalojanov et al. SGP 2012
Decompose into basic building blocks

source model

Liu et al. Eurographics 2015
Level-of-detail representations
Key idea

Distance from camera = less geometric detail required
Subdivision surfaces

• We saw them already

• Advantages
  o Very strong geometric compression (4 triangles become 1)
  o Theoretical convergence properties

• Disadvantages
  o Not applicable to downsample shapes that do not have this structure
Edge collapse

- Models can be downsampled by sequence of edge collapses

[Hoppe, Progressive Meshes, SIGGRAPH 1996]
Example result

[Hoppe, Progressive Meshes, SIGGRAPH 1996]