Advanced Computer Graphics
CSE 190 [Winter 2016], Lecture 6
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To Do
- Assignment 1, Due Jan 29
- Starting Geometry Processing
  - Assignment 2 due Feb 19
  - Please START EARLY
  - Contact us for difficulties, help finding partners etc.

Course Outline
- 3D Graphics Pipeline
  - Rendering (Creating, shading images from geometry, lighting, materials)
  - Modeling (Creating 3D Geometry)

Modeling
- Spline curves, surfaces: 70s – 80s
- Utah teapot: Famous 3D model
- More recently: Triangle meshes often acquired from real objects

Relevance to Course
- Main idea is to talk about mesh processing algs.
- Will learn to represent, work with meshes
- Do mesh simplification, progressive meshes

Unit 1: Foundations of Signal and Image Processing
Understanding the way 2D images are formed and displayed, the important concepts and algorithms, and to build an image processing utility like Photoshop
Weeks 1 – 3, Assignment 1

Unit 2: Meshes, Modeling
Weeks 3 – 5, Assignment 2 Feb 19
Outline for Today

Overview of types of 3D representations
- 3D objects can be represented in a variety of ways. We survey these today
- Before talking specifically about polygon meshes, which are often most common way

Much of material in this lecture courtesy Szymon Rusinkiewicz

3D Objects

How can this object be represented in a computer?

This one?

How about this one?

This one?
Types of 3D object data

- Polygon meshes for complex real-world objects
- Spline patches from modeling programs
- Volume data or voxels (e.g. visible human project)
- Machine parts (Constructive Solid Geometry)
- And a few more

All have advantages, disadvantages. Increasingly, meshes are easiest to use and simplest

Comparisons

- Efficient hardware rendering (meshes simple)
- Manipulation (edit, simplify, compress etc.)
  - Splines easiest originally, but now many algorithms for polygon meshes
- Acquisition or Modeling
  - Splines, CSG originally used for modeling
  - But increasingly, complex meshes acquired from real world
- Compactness
- Simplicity (meshes win big here)

Point Cloud

- Unstructured samples
- Advantage: simplicity
- Disadvantage: no information on adjacency / connectivity
  - Have to use e.g. k-nearest neighbors

Increasingly hot topic in graphics today

Range Image

- Image: stores an intensity / color along each of a set of regularly-spaced rays in space
- Range image: stores a depth along each of a set of regularly-spaced rays in space
- Obtained using devices known as range scanners
- Advantages:
  - Uniform (?) parameterization
  - Adjacency / connectivity information

Cyberware whole body 3D scanner

- Not a complete 3D description: does not include part of object occluded from viewpoint
Range Image

- Adjacency in range image not equal to adjacency on surface

Range Image Terminology

- Range images
- Range surfaces
- Depth images
- Depth maps
- Height fields
- 2½-D images
- Surface profiles
- xyz maps
- ...

Mesh

Connected set of polygons (usually triangles)
- May not be closed
- Representation (simplest): Vertices, Indexed Face Set
- Focus of your assignment and easy to work with

Polygon Soup

- Unstructured set of polygons:
  - Often the output of interactive modeling systems
  - Often sufficient for rendering, but not other operations

Subdivision Surface

- Coarse mesh + subdivision rule
  - Smooth surface is limit of refinements
### Current Research

- All representations described are widely used, and topics of current research
- Range images, and combinations to construct entire surfaces widely used (3D photography, 3D objects in movies, …)
- Triangle meshes perhaps most common
- Subdivision surfaces commonly used in movies, …
- Point clouds becoming increasingly relevant
- Replace older representations in many cases (parametric, spline patches, CSG, etc.)

### Parametric Surface

- Tensor product spline patches
  - Careful constraints to maintain continuity

### Implicit Surfaces

- Points satisfying: \( F(x,y,z) = 0 \)

### Why Implicit Surfaces?

- Function usually sampled regularly (voxel grid)
  - Can guarantee that model is hole-free
  - Easy to change topology
  - Algorithms must traverse volume: slow
  - More space than parametric representation

### Voxels

- Uniform grid of occupancy, density, etc.
  - Often acquired from CAT, MRI, etc.

### Constructive Solid Geometry

- Hierarchy of boolean operations (union, difference, intersect) applied to simple shapes
Scene Graph
- Union of objects at leaf nodes

Skeleton
- Graph of curves with radii

Application-Specific Models
- Domain-specific semantic information + geometry

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3D Objects
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3D Objects

This one?

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