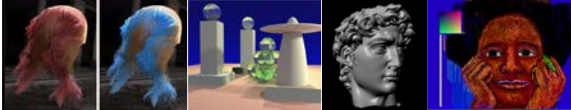


Advanced Computer Graphics

CSE 163 [Spring 2017], Lecture 6

Ravi Ramamoorthi

<http://www.cs.ucsd.edu/~ravr>

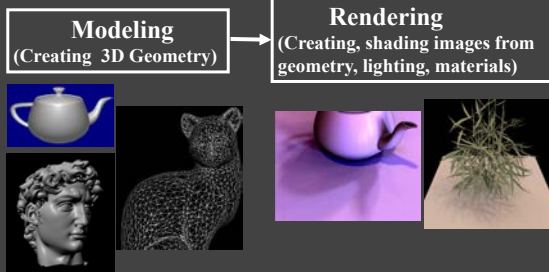


To Do

- Assignment 1, Due Apr 28
- Starting Geometry Processing
 - Assignment 2 due May 19
 - Please START EARLY
 - Contact us for difficulties, help finding partners etc.

Course Outline

- 3D Graphics Pipeline



Course Outline

- 3D Graphics Pipeline

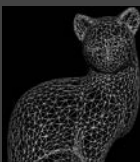


Unit 1: Foundations of Signal and Image Processing
Understanding the way 2D images are formed and displayed, the important concepts and algorithms, and to build an image processing utility like Photoshop
Weeks 1 – 3. **Assignment 1**

Unit 2: Meshes, Modeling
Weeks 3 – 5. **Assignment 2 Feb 19**

Modeling

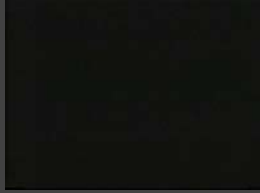
- Spline curves, surfaces: 70^s – 80^s
- Utah teapot: Famous 3D model
- More recently: Triangle meshes often acquired from real objects



Relevance to Course

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

Progressive Mesh Movie



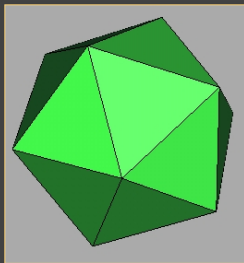
Outline for Today

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?

3D Objects



H&B Figure 10.46

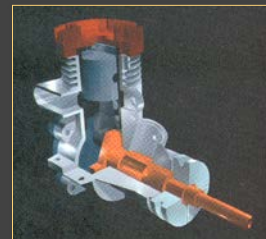
This one?

3D Objects



How about this one?

3D Objects



H&B Figure 9.9

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



Hoppe

Range Image

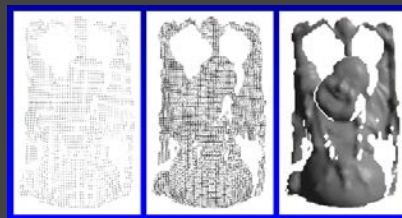
- Image: stores an intensity / color along each of a set of regularly-spaced rays in space
- Range image: stores a depth along each of a set of regularly-spaced rays in space
- Obtained using devices known as range scanners
- Advantages:
 - Uniform (?) parameterization
 - Adjacency / connectivity information

Cyberware whole body 3D scanner



Range Image

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

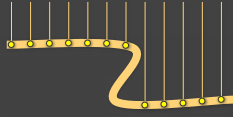


Range Image Tessellation Range Surface

Curless

Range Image

- Adjacency in range image not equal to adjacency on surface



Range Image

- Adjacency in range image not equal to adjacency on surface



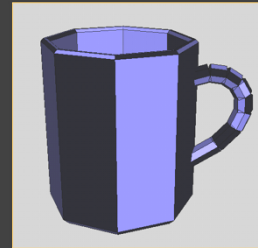
- Avoid connecting across these discontinuities
 - Heuristic: depth threshold

Range Image Terminology

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

Polygon Soup

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

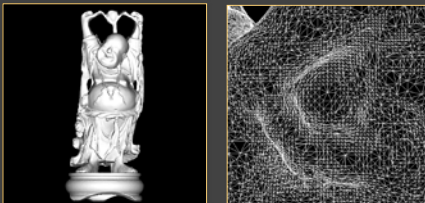


Larson

Mesh

Connected set of polygons (usually triangles)

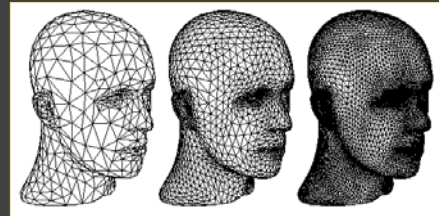
- May not be closed
- Representation (simplest): Vertices, Indexed Face Set
- Focus of your assignment and easy to work with



Curless

Subdivision Surface

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



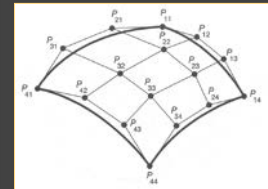
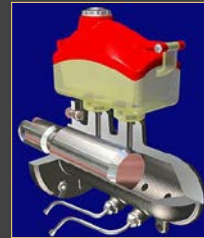
Zorin & Schroder

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



FvDFH

Implicit Surfaces

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



Polygonal Model



Implicit Model

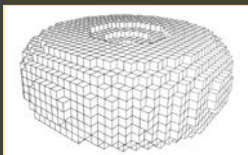
Lorensen

Why Implicit Surfaces?

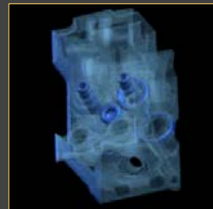
- Function usually sampled regularly (voxel grid)
- + Can guarantee that model is hole-free
 + Easy to change topology
 - Algorithms must traverse volume: slow
 - More space than parametric representation

Voxels

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



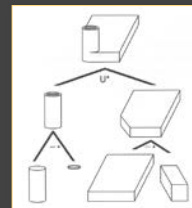
FvDFH Figure 12.20



Stanford Graphics Laboratory

Constructive Solid Geometry

- Hierarchy of boolean operations (union, difference, intersect) applied to simple shapes



FvDFH Figure 12.27



H&B Figure 9.9

Scene Graph

- Union of objects at leaf nodes



Bell Laboratories



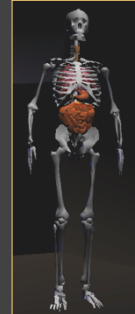
avalon.viewpoint.com

Skeleton

- Graph of curves with radii



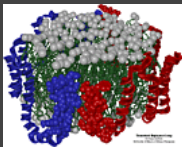
Stanford Graphics Laboratory



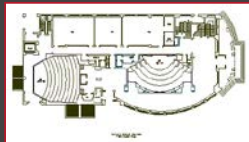
SGI

Application-Specific Models

- Domain-specific semantic information + geometry

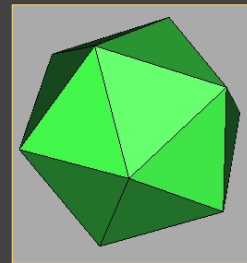


Apo A-1
(Theoretical Biophysics Group,
University of Illinois at Urbana-Champaign)



Architectural Floorplan
(CS Building, Princeton University)

3D Objects



How can this object be represented in a computer?

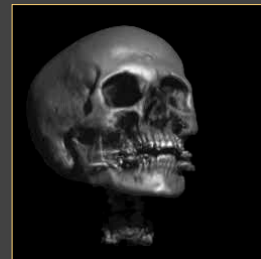
3D Objects



H&B Figure 10.46

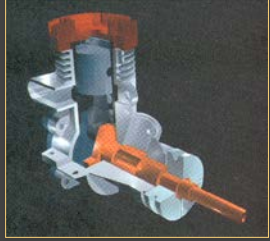
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H&B Figure 9.9

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