Advanced Computer Graphics

CSE 163 [Spring 2018], Lecture 6

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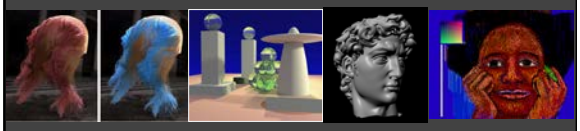


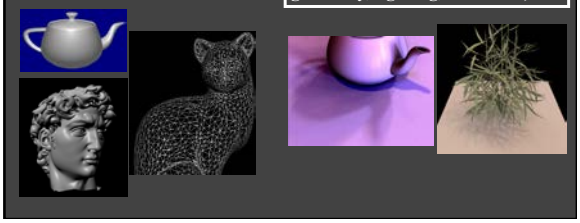
To Do

- Assignment 1, Due Apr 27
- Starting Geometry Processing
  - Assignment 2 due May 18
  - Please START EARLY
  - Contact us for difficulties, help finding partners etc.

Course Outline

- 3D Graphics Pipeline

Modeling (Creating 3D Geometry) → **Rendering** (Creating, shading images from geometry, lighting, materials)



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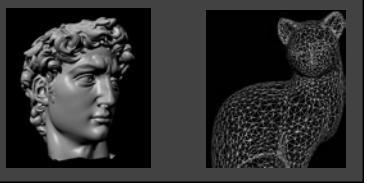
Unit 1: Foundations of Signal and Image Processing
Understanding the way 2D images are formed and displayed, the important concepts and algorithms, and to build an image processing utility like Photoshop
Weeks 1 – 3. **Assignment 1**

Unit 2: Meshes, Modeling
Weeks 3 – 5. **Assignment 2 May 18**

Modeling

- Spline curves, surfaces: 70^s – 80^s
- Utah teapot: Famous 3D model

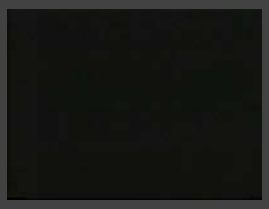
- More recently: Triangle meshes often acquired from real objects



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



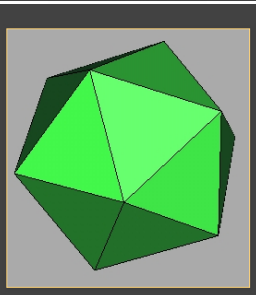
Outline for Today

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



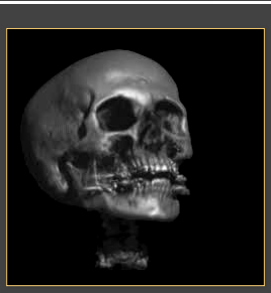
How can this object be represented in a computer?

3D Objects

H&B Figure 10.46

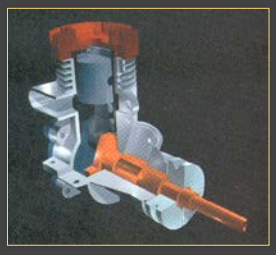
This one?

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

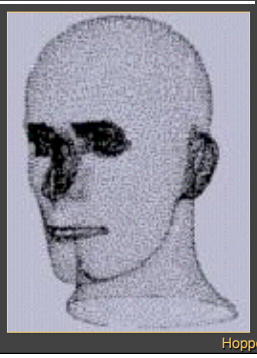
Comparisons

- 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

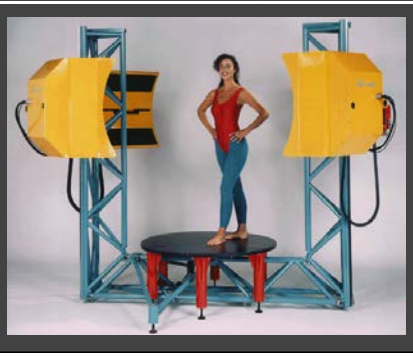


Hoppe

Range Image

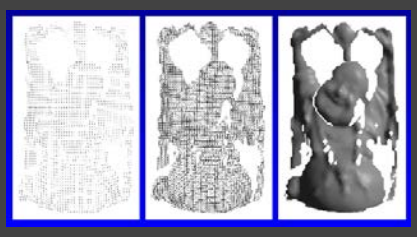
- Image: stores an intensity / color along each of a set of regularly-spaced rays in space
- Range image: stores a depth along each of a set of regularly-spaced rays in space
- Obtained using devices known as range scanners
- Advantages:
  - Uniform (?) parameterization
  - Adjacency / connectivity information

Cyberware whole body 3D scanner



Range Image

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

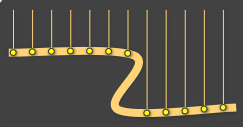


Range Image Tessellation Range Surface

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

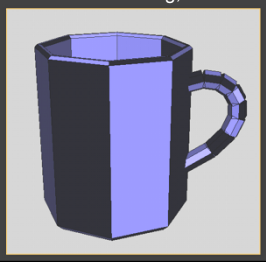
- Avoid connecting across these discontinuities
  - Heuristic: depth threshold

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

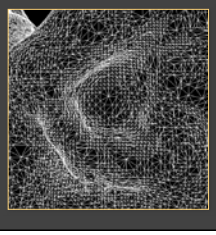


Larson

Mesh

Connected set of polygons (usually triangles)

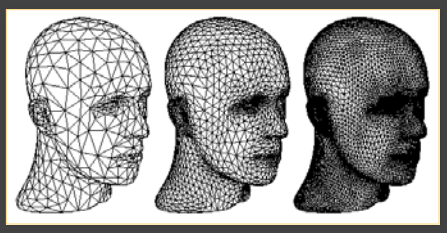
- May not be closed
- Representation (simplest): Vertices, Indexed Face Set
- Focus of your assignment and easy to work with



Curless

Subdivision Surface

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



Zorin & Schroder

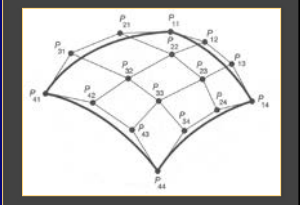
Current Research

- 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

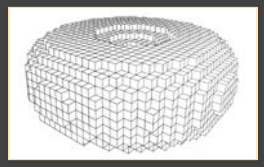
Why Implicit Surfaces?

- Function usually sampled regularly (voxel grid)

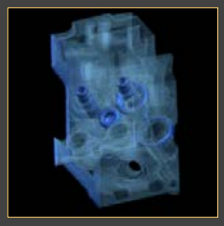
+ Can guarantee that model is hole-free
+ Easy to change topology
− Algorithms must traverse volume: slow
− More space than parametric representation

Voxels

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



FvDFH Figure 12.20



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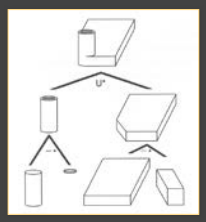
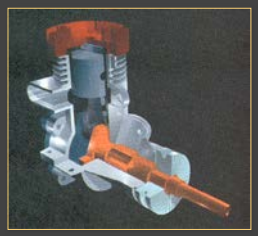
Constructive Solid Geometry

- 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

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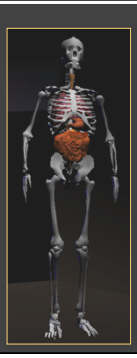
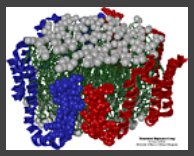


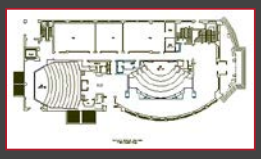
SGI

Application-Specific Models

- Domain-specific semantic information + geometry

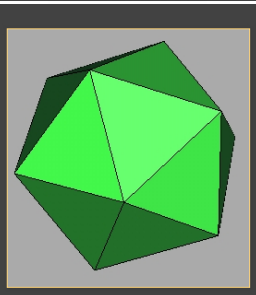


Apo A-1
(Theoretical Biophysics Group, University of Illinois at Urbana-Champaign)



Architectural Floorplan
(CS Building, Princeton University)

3D Objects



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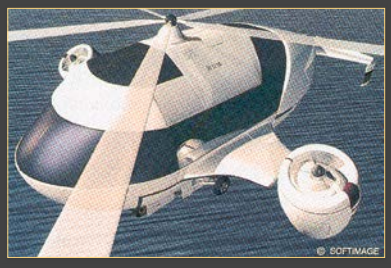

H&B Figure 10.46

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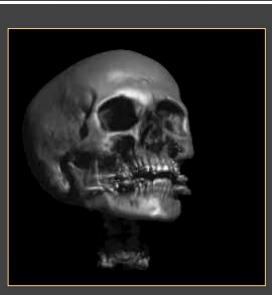
3D Objects



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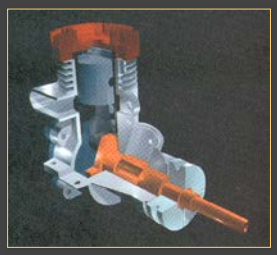

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