3D Modeling I

CG08b
Lior Shapira
Lecture 8

Based on:
Thomas Funkhouser,Princeton University

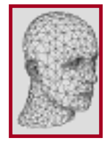
Course Syllabus

- I. Image processing
- II. Rendering
- **III. Modeling**
- IV. Animation

Image Processing
(Rusty Coleman, CS426, Fall99)

Rendering
(Michael Bostock, CS426, Fall99)

Modeling
(Dennis Zorin, CalTech)



Animation
(Angel, Plate 1)

Modeling

- How do we ...
  - Represent 3D objects in a computer?
  - Acquire computer representations of 3D objects?
  - Manipulate computer representations of 3D objects?



3D Objects

How can this object be represented in a computer?

3D Objects

H&B Figure 10.46

This one?

3D Objects

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How about this one?

3D Objects


H&B Figure 9.9

This one?

3D Objects

This one?

3D Object Representations

- Points
  - Point cloud
  - Range image
- Surfaces
  - Polygonal Mesh
  - Subdivision
  - Parametric
  - Implicit
- Solids
  - Voxels
  - BSP tree
  - CSG
  - Sweep
- High-level structures
  - Scene graph
  - Application specific

Equivalence of Representations

- Thesis:
  - Each representation has enough expressive power to model the shape of any geometric object
  - It is possible to perform all geometric operations with any fundamental representation
- Analogous to Turing-equivalence
  - Computers / programming languages Turing-equivalent. But each does different things better!

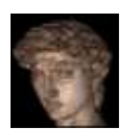
Why different Representations?

- Efficiency for different tasks
  - Acquisition
  - Rendering
  - Manipulation
  - Animation
  - Analysis

Data Structures determine algorithms!

Modeling Operations

- What can we do with a 3D object representation?
  - Edit
  - Transform
  - Smooth
  - Render
  - Animate
  - Morph
  - Compress
  - Transmit
  - Analyze
  - …


Digital Michealangelo


Pirates of the carribean


Smoothing

3D Object Representations

- Desirable properties depend on intended use
  - Easy to acquire
  - Accurate
  - Concise
  - Intuitive editing
  - Efficient editing
  - Efficient display
  - Efficient intersections
  - Guaranteed validity
  - Guaranteed smoothness
  - …

Outline

- Points
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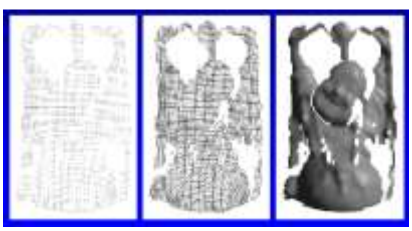
Range Image

- Set of 3D points mapping to pixels of depth image
  - Acquired from range scanner



Range Image Tesselation Range Surface

Brian Curless SIGGRAPH 99 Course #4 Notes

Point Cloud

- Unstructured set of 3D point samples
  - Acquired from range finder, computer vision, etc

Hugues Hoppe

Hugues Hoppe

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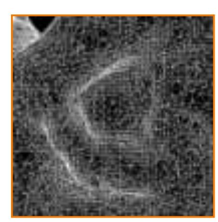
Polygonal Mesh

- Connected set of polygons (usually triangles)



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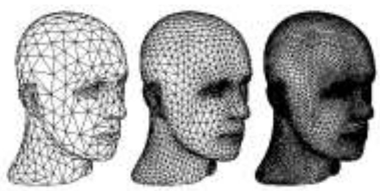
Subdivision Surface

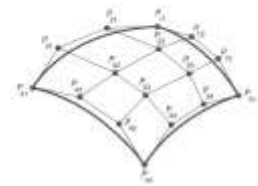
- Coarse mesh & subdivision rule
  - Define smooth surface as limit of sequence of refinements



Zorin & Schroeder
SIGGRAPH 99
Course Notes

Parametric Surface

- Tensor product spline patchs
  - Each patch is a parametric function
  - Careful constraints to maintain continuity



FvDFH Figure 11.44

Implicit Surface

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

Polygonal Model

Implicit Model

Bill Lorensen
SIGGRAPH 99
Course #4 Notes

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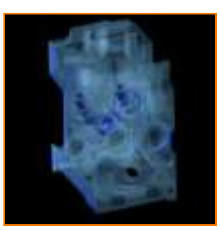
Voxels

- Uniform grid of volumetric samples
  - Acquired from CAT, MRI, etc.

FvDFH Figure 12.20



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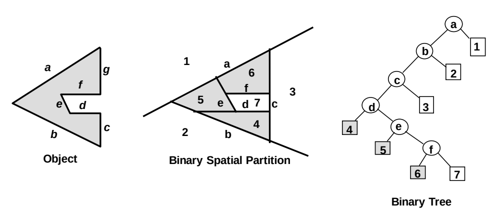
BSP Tree

- Binary space partition with solid cells labeled
  - Constructed from polygonal representations



Naylor

CSG (constructive solid geometry)

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

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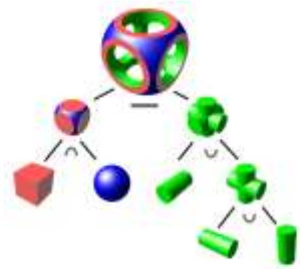

Sweep

- Solid swept by curve along trajectory


Removal Path


Sweep Model

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Scene Graph

- Union of objects at leaf nodes


Bell Laboratories

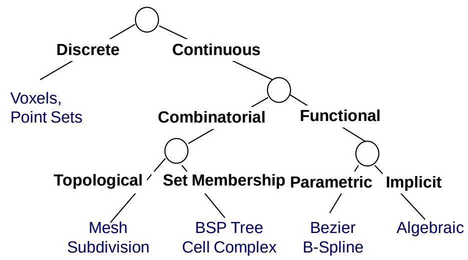

avalon.viewpoint.com

Application Specific


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


Architectural Floorplan
(CS Building, Princeton University)

Taxonomy of 3D Representations



Naylor

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Computational Differences

- Efficiency
  - Combinatorial complexity (e.g. O(n log n))
  - Space/time trade-offs (e.g. z-buffer)
  - Numerical accuracy/stability (degree of polynomial)
- Simplicity
  - Ease of acquisition
  - Hardware acceleration
  - Software creation and maintenance
- Usability
  - Designer interface vs. computational engine