CS 526: Advanced Computer Graphics

Thomas Funkhouser

Fall 2006

Background

- Image Processing
  - Basic signal processing
  - Filtering, resampling, warping, …
- Rendering
  - Polygon rendering pipeline
  - Ray tracing
- Modeling
  - Basic 3D object representations
  - Polygonal meshes
- Animation
  - Basic principles

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  - Polygon rendering pipeline
  - OpenGL
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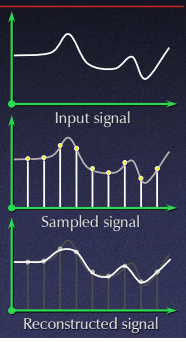

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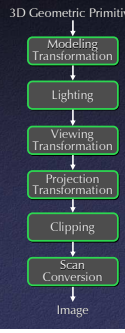

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Angel, Plate I

CS526 Syllabus

- Geometric modeling
  - Polygonal meshes
  - Subdivision surfaces
  - Splines
  - Volumetric representations
- Image-based modeling and rendering
  - Plenoptic function
  - Light fields
  - Imposters
- Global illumination
  - Lighting models
  - Simulating light transport
  - Visibility
- Analysis & Manipulation
  - Registration
  - Matching
  - Segmentation
  - Deformation

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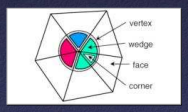

Hoppe

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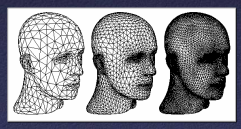

Zorin & Shroeder

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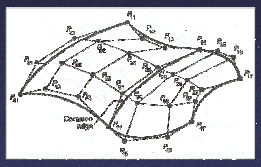

FvDFH Figure 11.43

CS526 Syllabus

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Turk

CS526 Syllabus

- Image-based Modeling and Rendering
  - Plenoptic function
  - Light fields
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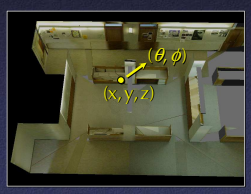

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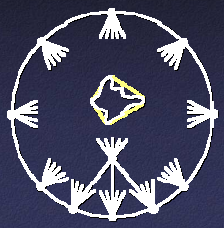

CS526 Syllabus

- Image-based Modeling and Rendering
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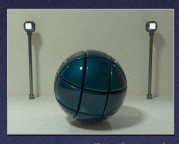
Aliaga

CS526 Syllabus

- Global Illumination
  - Lighting models
  - Simulating light transport
  - Visibility



Greenberg et al.

CS526 Syllabus

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Jensen

CS526 Syllabus

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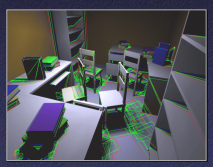

Drettakis

CS526 Syllabus

- Analysis & Manipulation
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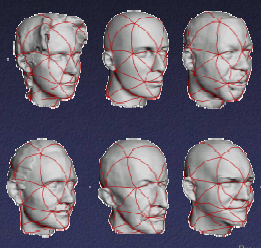
  - Deformation
  - Segmentation



Praun

CS526 Syllabus

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Alexa

CS526 Syllabus

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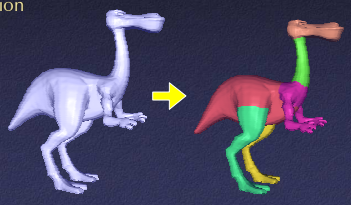


Katz

Coursework

- Written assignments
- 3 Programming assignments
- Final project

Modeling: Which Object Representation?

Why Different Representations?

- Represent different kinds of information
  - Point data
  - Surface data
  - Volumetric data
  - Higher-level structure

Why Different Representations?

- Efficiency for different tasks
  - Rendering (e.g., with hardware acceleration)
  - Manipulation (simplification, compression, etc.)
  - Acquisition
  - Similarity comparisons, indexing, search
- Advantageous properties
  - Compactness of representation
  - User control for creation or manipulation
  - Simplicity

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
- Data structures determine algorithms

Naylor

3D Object Representations

- Point data
  - Point cloud
  - Range image
- Surface data
  - Polygon soup
  - Mesh
  - Subdivision
  - Parametric
- Volumetric data
  - Implicit functions
  - Voxel grids
  - BSP tree
  - CSG
- Others
  - Scene graph
  - Shape signatures

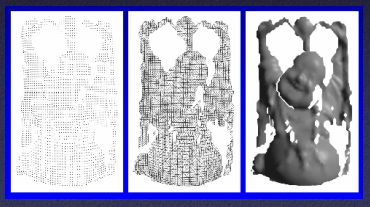
Point Cloud

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

Hoppe

Range Image

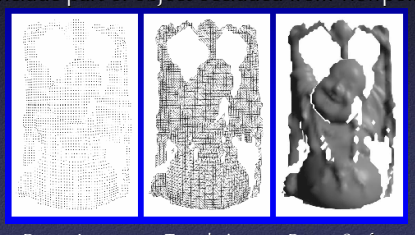
- Image with a depth along each of a set of regularly-spaced rays in space



Range Image Tesselation Range Surface

Range Image

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

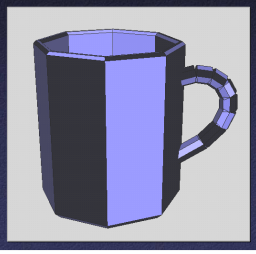


Range Image Tesselation Range Surface

Curless

Polygon Soup

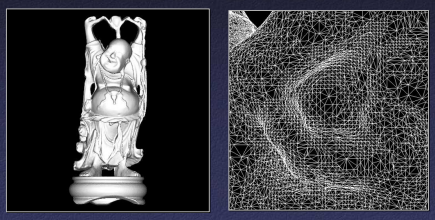
- Unstructured set of polygons
  - Often the output of interactive modeling systems



Larson

Mesh

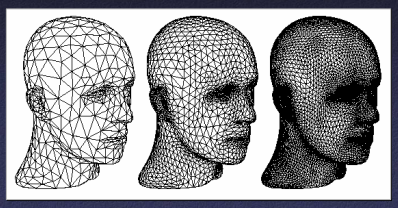
- Connected set of polygons (usually triangles)
  - May not be closed



Curless

Subdivision Surface

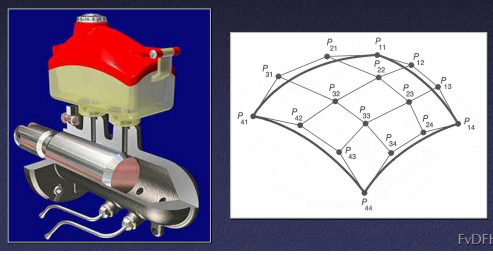
- Coarse mesh + subdivision rule
  - Smooth surface is limit of refinements



Zorin & Schroeder

Parametric Surface

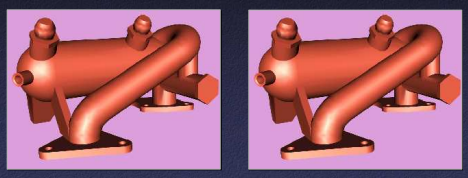
- Tensor product spline patches
  - Careful constraints to maintain continuity



FvDFH

Implicit Surfaces

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

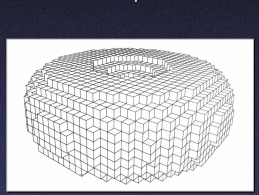


Polygonal Model | Implicit Model

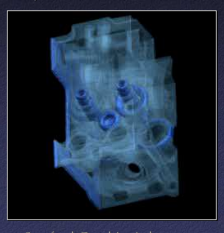
Lorensen

Voxels

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



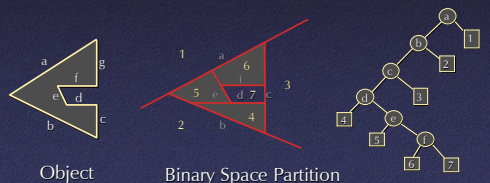
FvDFH Figure 12.20



Stanford Graphics Laboratory

BSP Tree

- Binary Space Partition with solid cells labeled
  - Constructed from polygonal representations
- Other hierarchical data structures: k-d trees, octrees

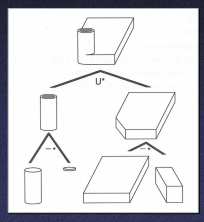


Object | Binary Space Partition | Tree

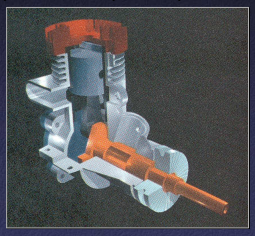
Naylor

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

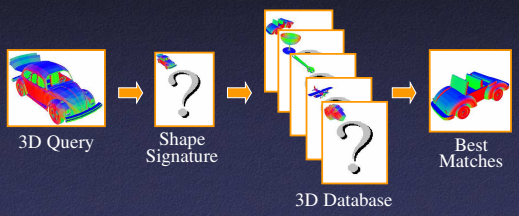
- Union of objects at leaf nodes

Bell Laboratories

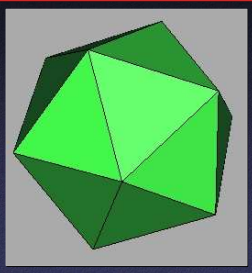
avalon.viewpoint.com

Shape Signature

- Indexible representation of shape

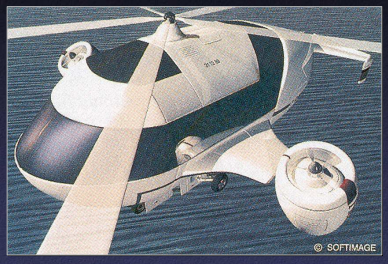


3D Objects



How can this object be represented in a computer?

3D Objects



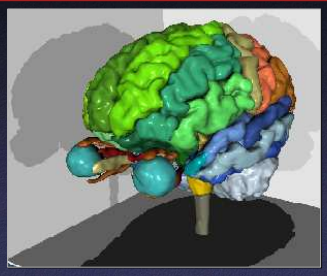
H&B Figure 10.46

This one?

3D Objects

How about this one?

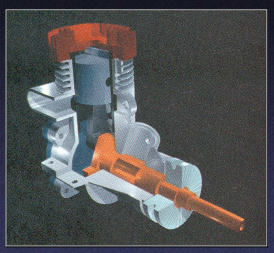
3D Objects



Lorensen

This one?

3D Objects



H&B Figure 9.9

This one?

3D Objects

This one?

http://www.cs.princeton.edu/courses/cos526/