Review of 3D Object Representations

Thomas Funkhouser

Princeton University

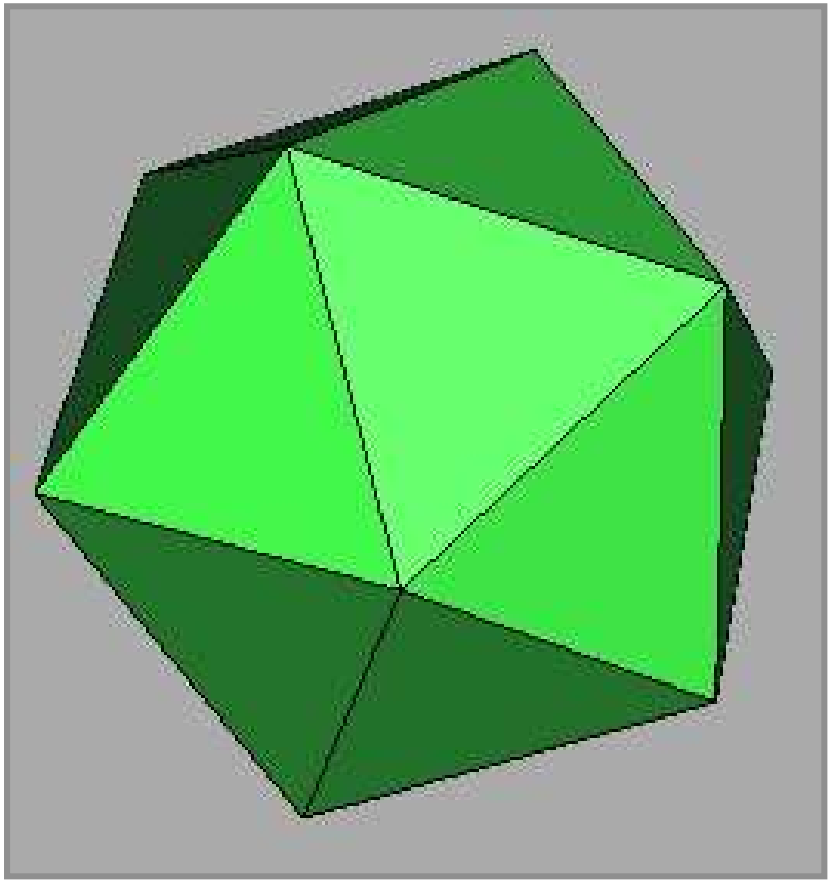
C0S 598B, Spring 2000

Goal

- Develop algorithms for analysis of 3D models
  - Reconstruction
  - Segmentation
  - Feature detection
  - Labeling
  - Matching
  - Classification
  - Retrieval
  - Recognition
  - Clustering

Different methods for different object representations

3D Objects



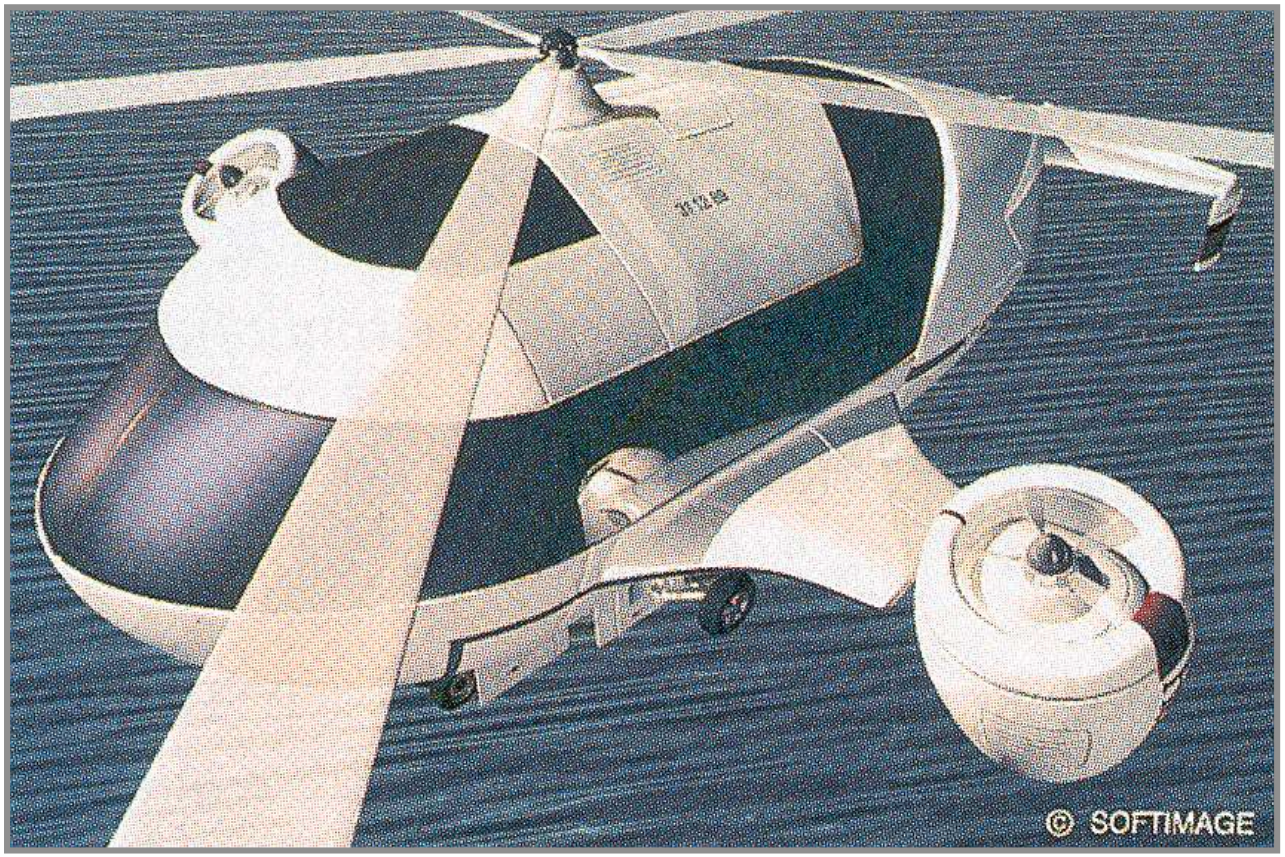
How can this object be represented in a computer?

3D Objects

Stanford Graphics Laboratory

How about this one?

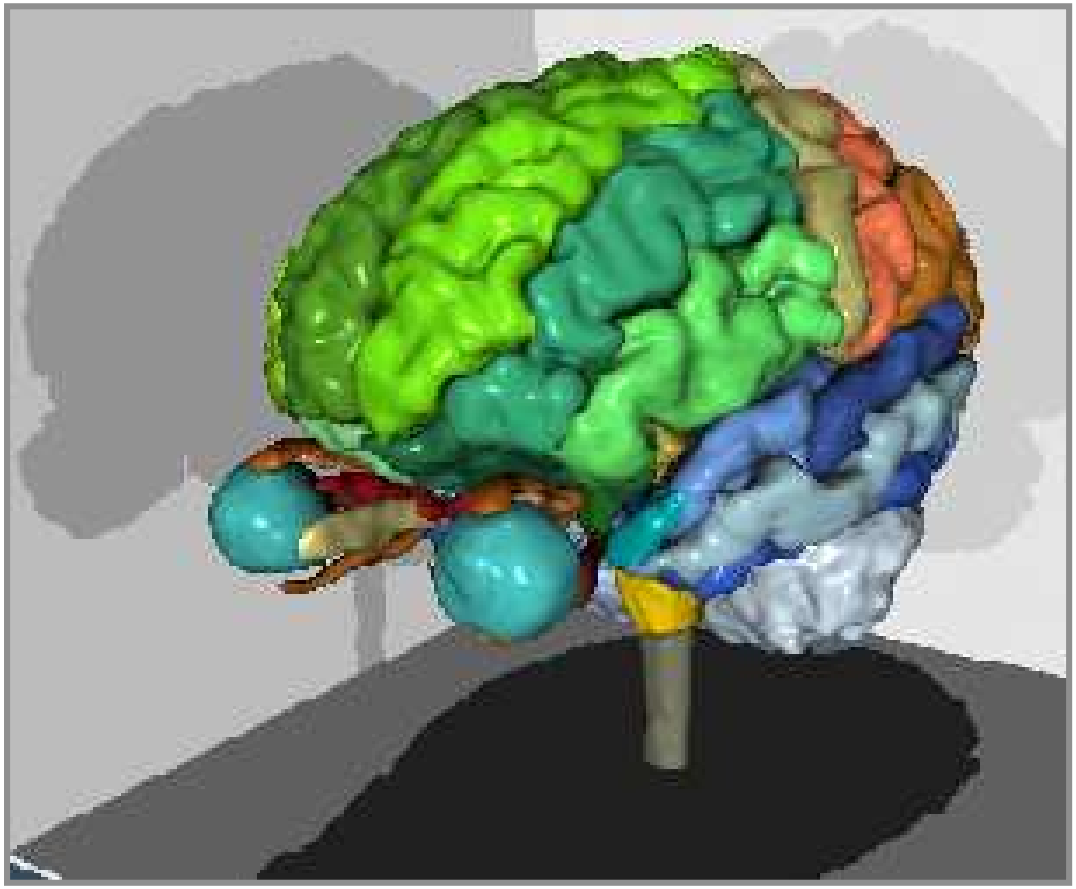
3D Objects



H&B Figure 10.46

This one?

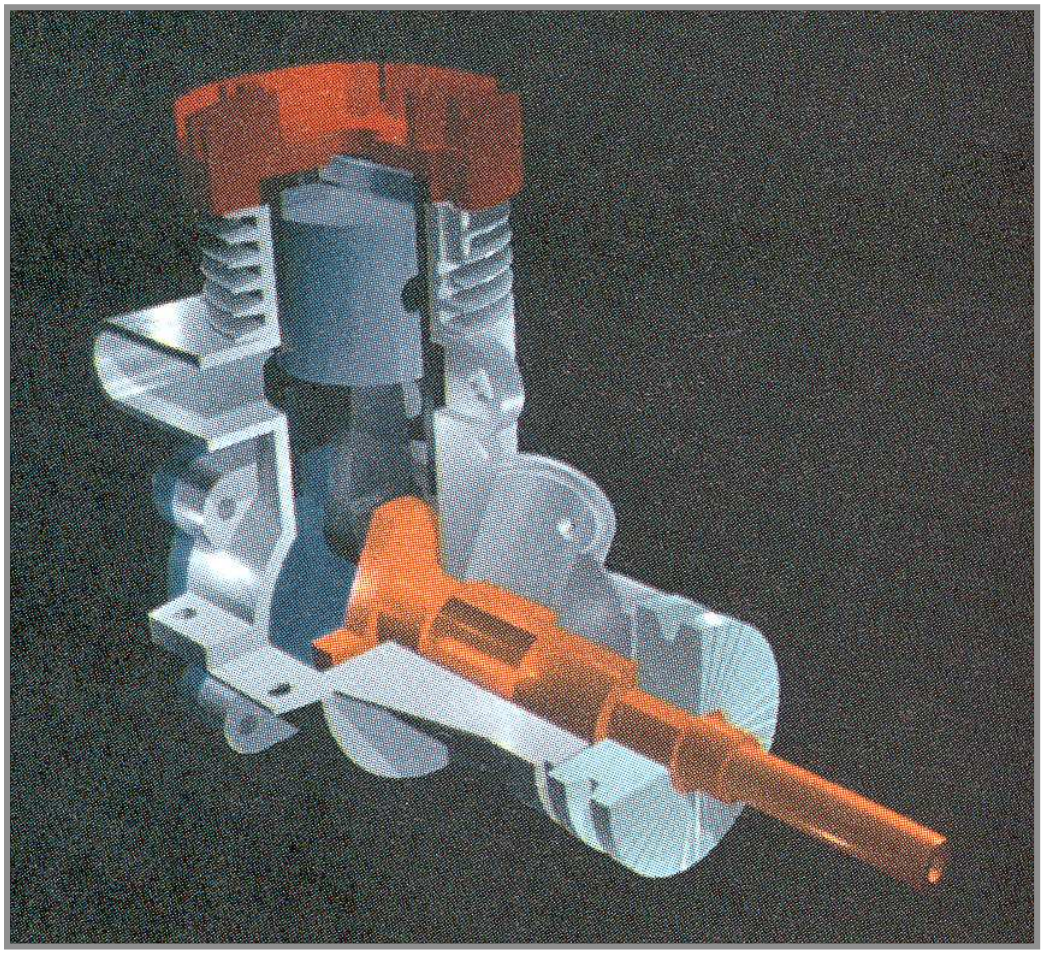
3D Objects



Lorensen

This one?

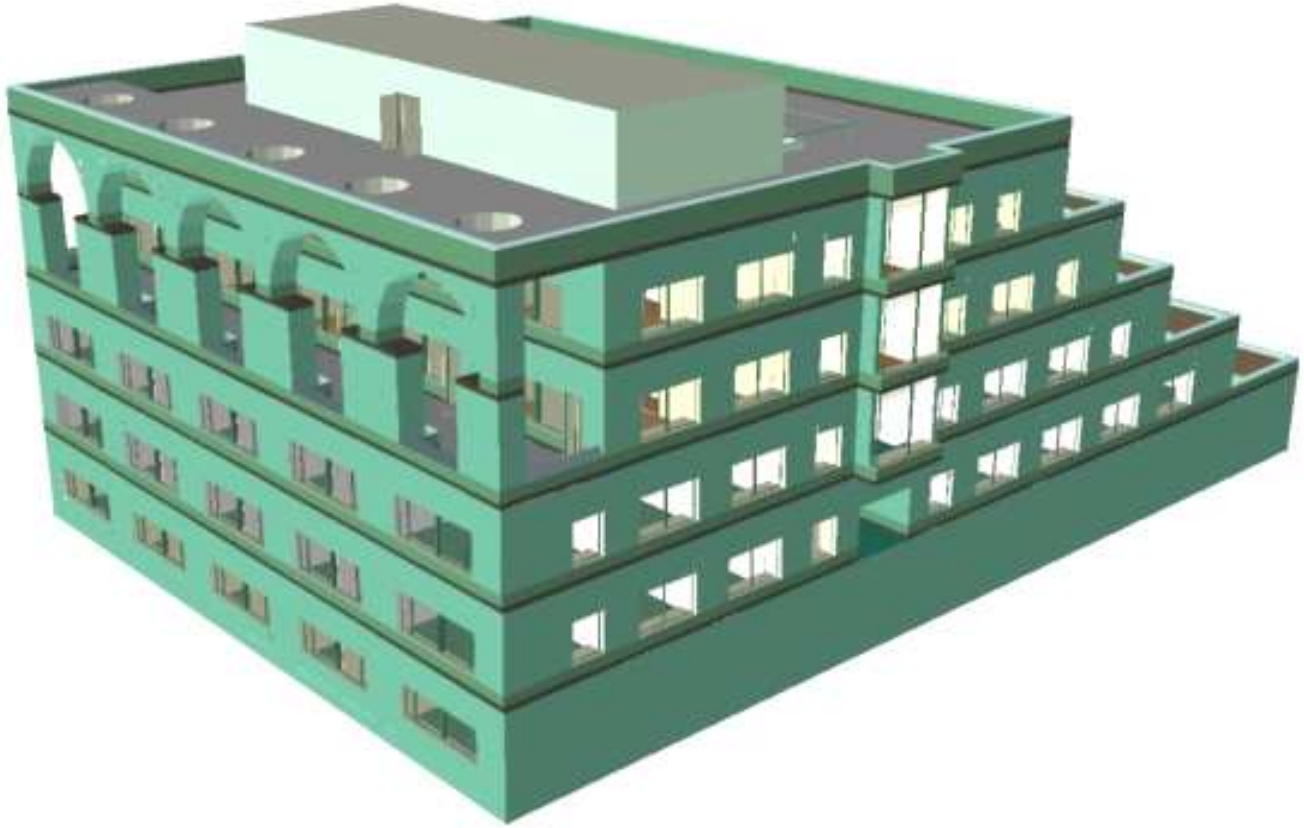
3D Objects



H&B Figure 9.9

This one?

3D Objects



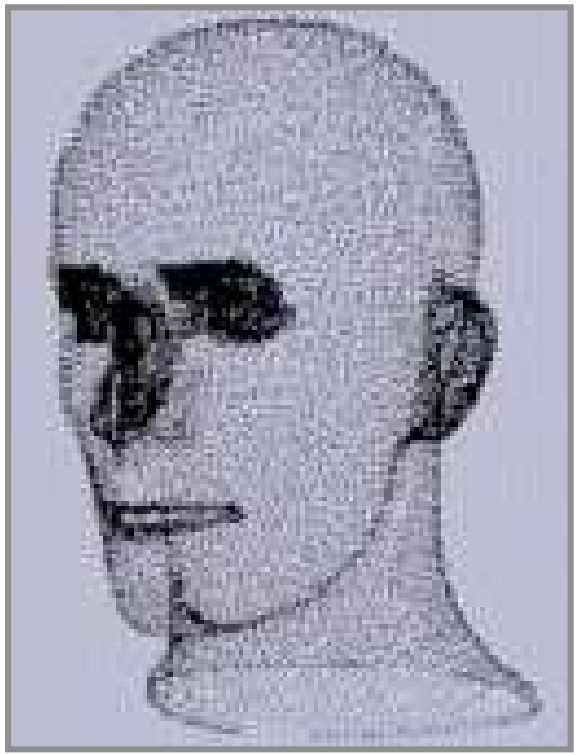
This one?

3D Object Representations

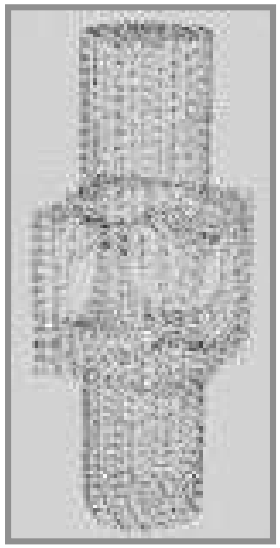
- Raw data
  - Point cloud
  - Range image
  - Polygon soup
- Surfaces
  - Mesh
  - Subdivision
  - Parametric
  - Implicit
- Solids
  - Voxels
  - BSP tree
  - Cell complex
- High-level structures
  - CSG
  - Constrained blocks
  - Generative model
  - Skeleton
  - Sweep
  - Scene graph

Point Cloud

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

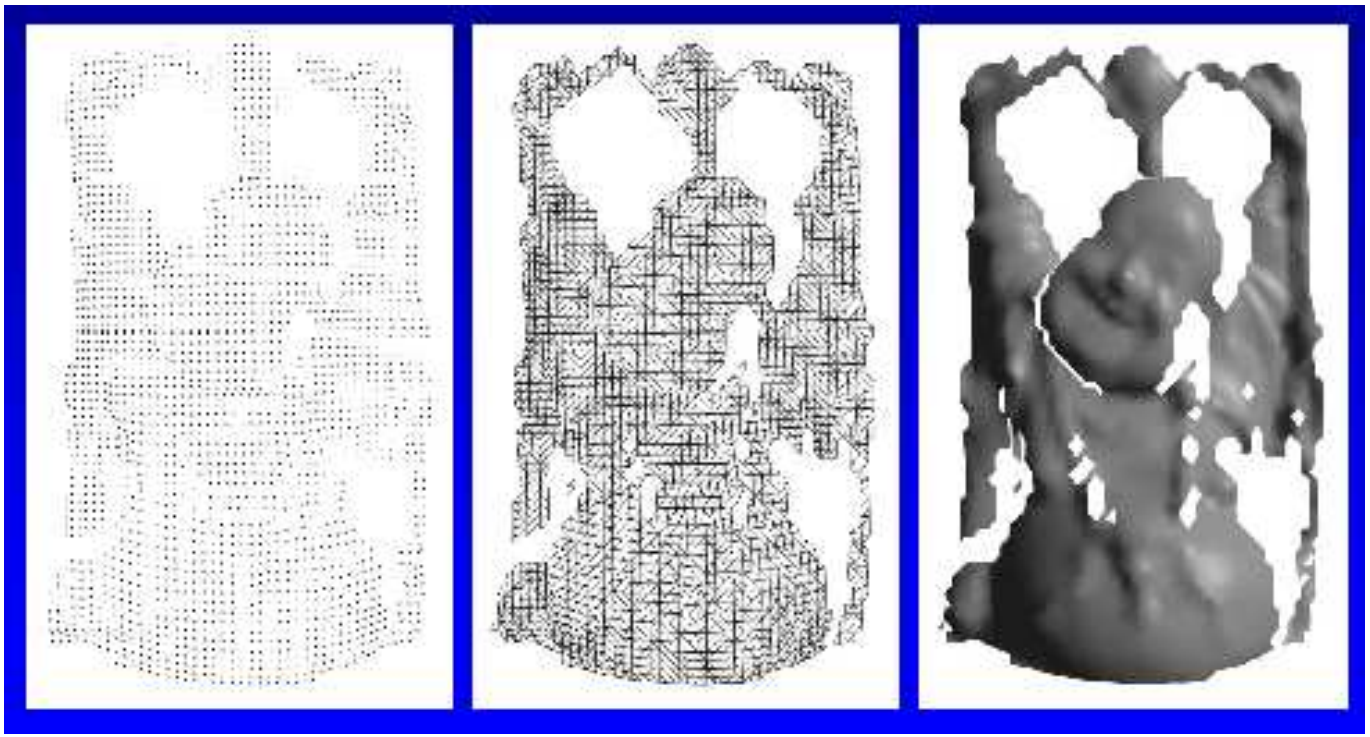


Hoppe



Hoppe

Range Image

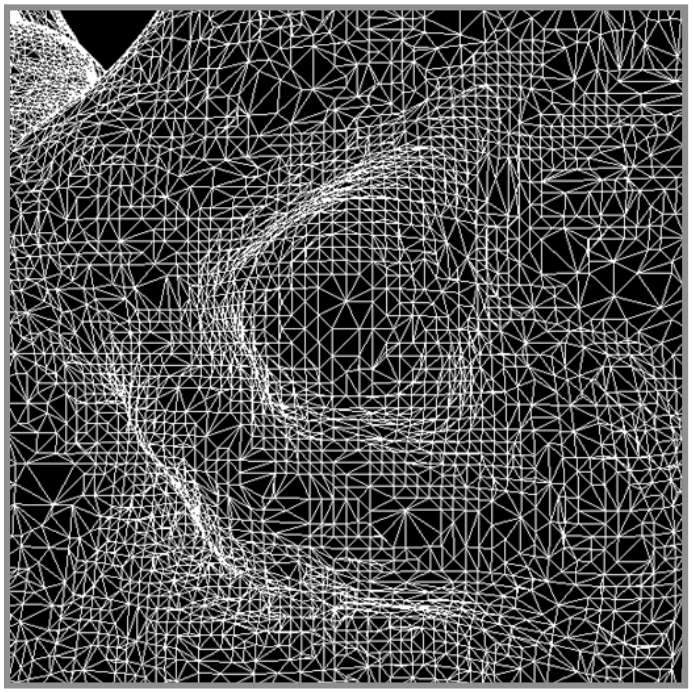


- Set of 3D points mapping to pixels of depth image
  - Acquired from range scanner

Range Image Tesselation Range Surface

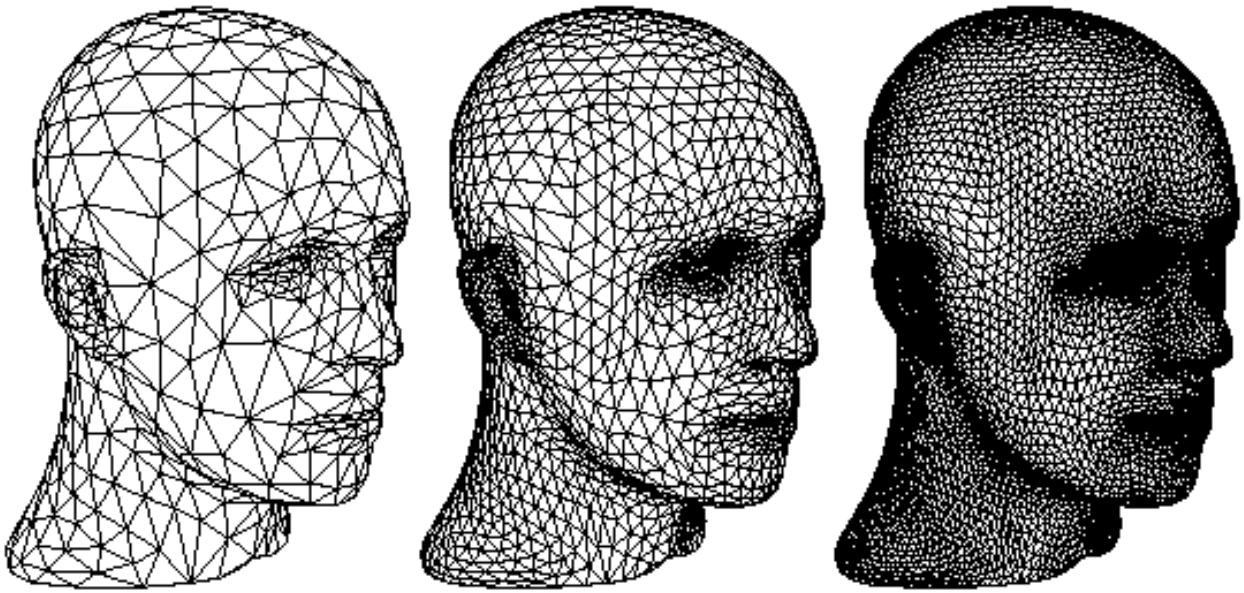
Mesh

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



Subdivision Surface

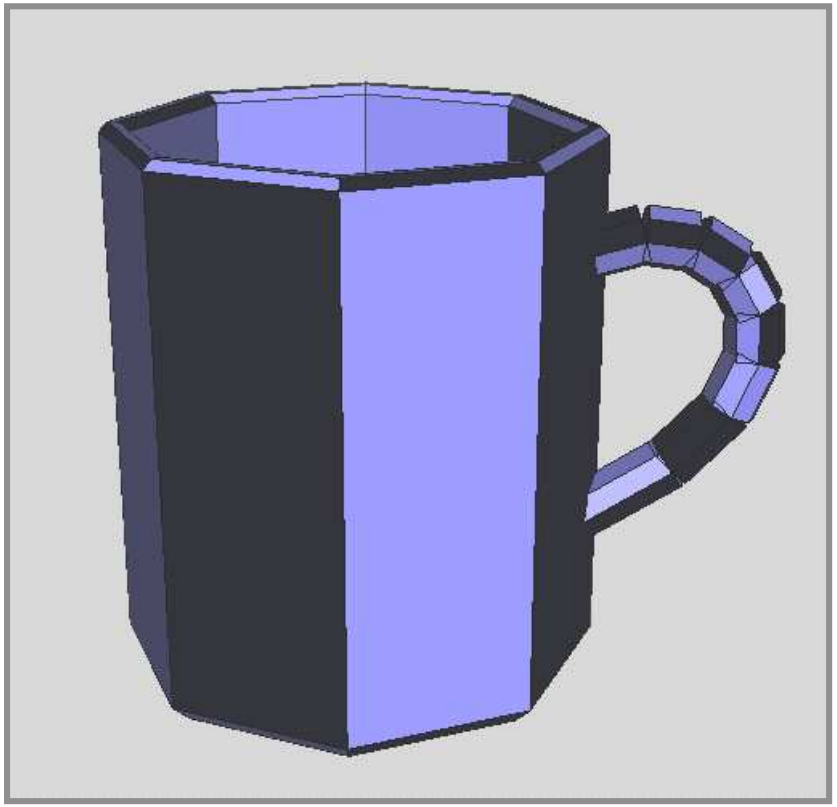
- Coarse mesh & subdivision rule
  - Define smooth surface as limit of sequence of refinements



Zorin & Schroeder
SIGGRAPH 99
Course Notes

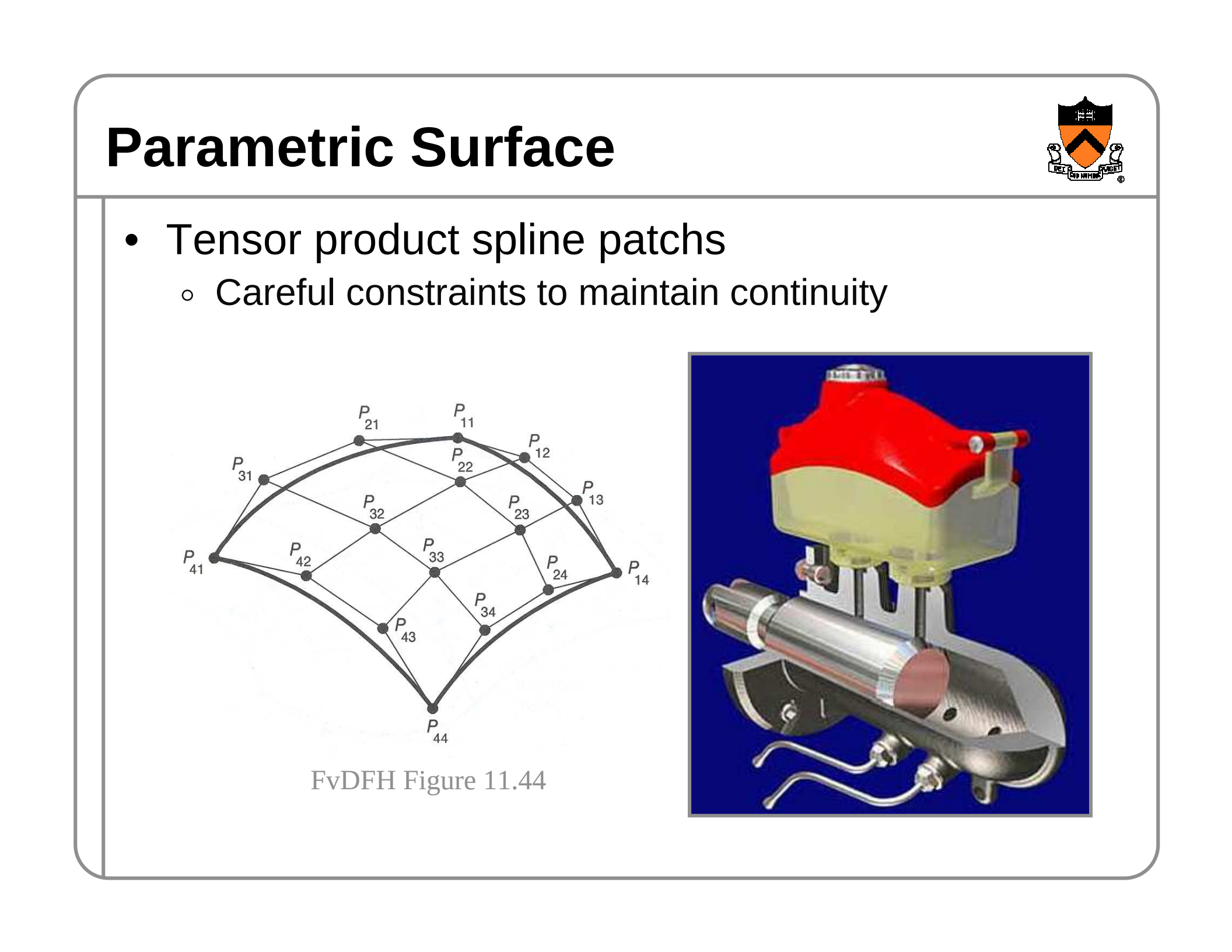
Polygon Soup

- Unstructured set of polygons
  - Created with interactive modeling systems?



Larson

Parametric Surface

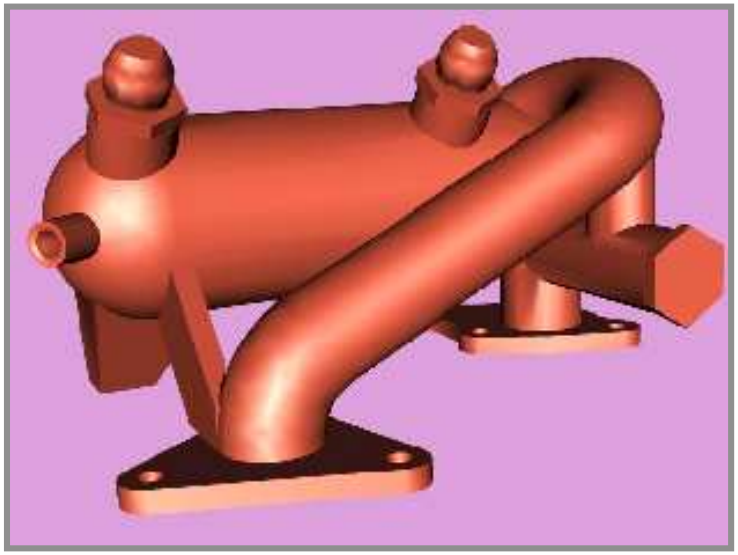


- Tensor product spline patchs
  - Careful constraints to maintain continuity

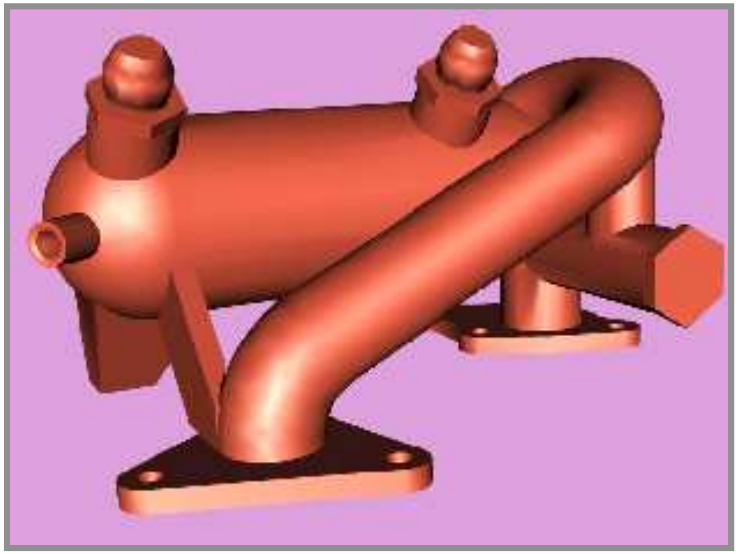
FvDFH Figure 11.44

Implicit Surface

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



Polygonal Model



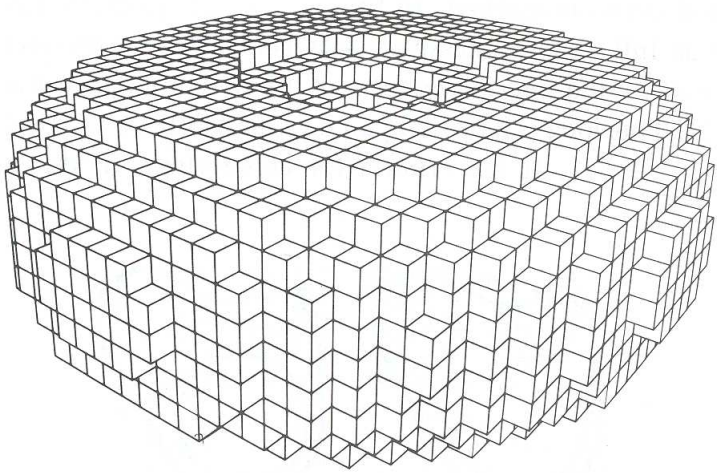
Implicit Model

3D Object Representations

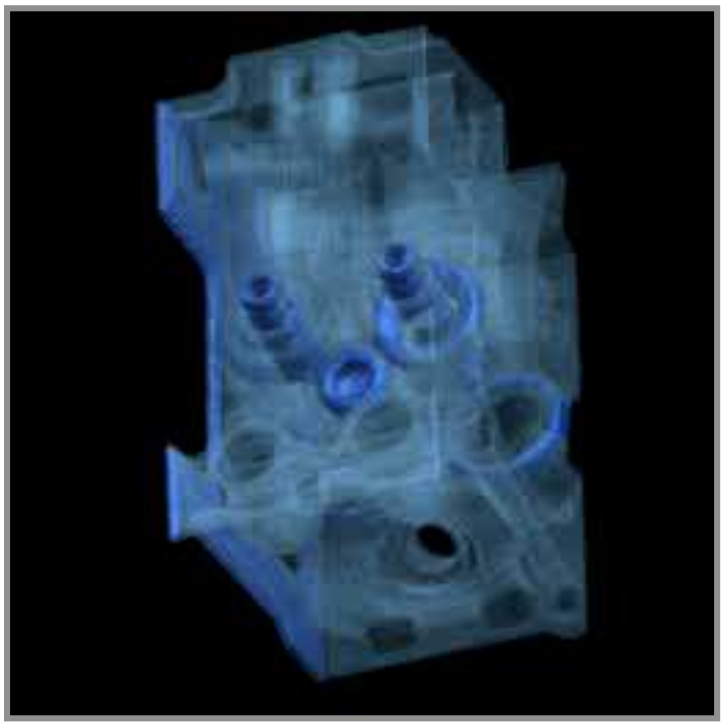
- Raw data
  - Point cloud
  - Range image
  - Polygon soup
- Surfaces
  - Mesh
  - Subdivision
  - Parametric
  - Implicit
- Solids
  - Voxels
  - BSP tree
  - Cell complex
- High-level structures
  - CSG
  - Constrained blocks
  - Generative model
  - Skeleton
  - Sweep
  - Scene graph

Voxels

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



FvDFH Figure 12.20



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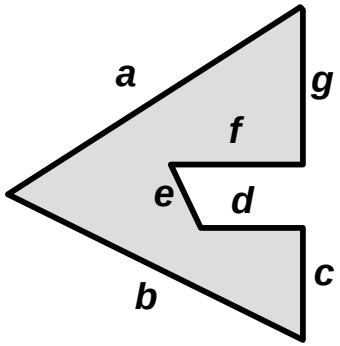
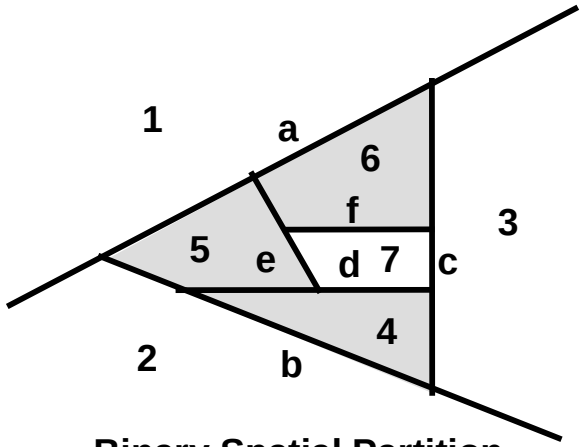
BSP Tree

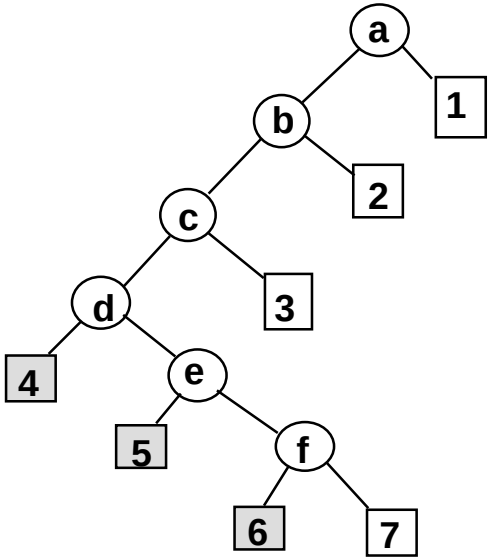
- Binary space partition with solid cells labeled
  - Constructed from polygonal representations



Object



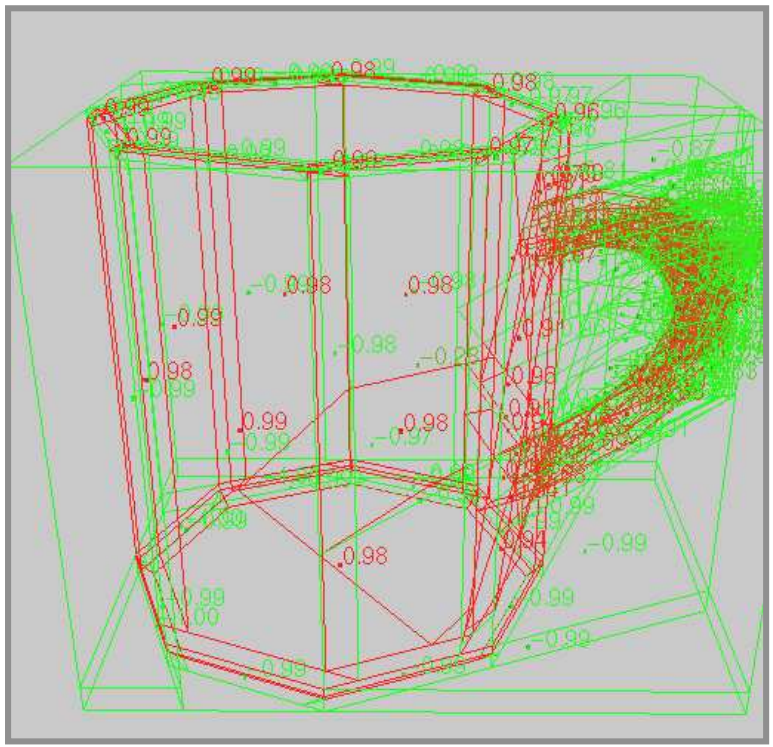
Binary Spatial Partition



Binary Tree

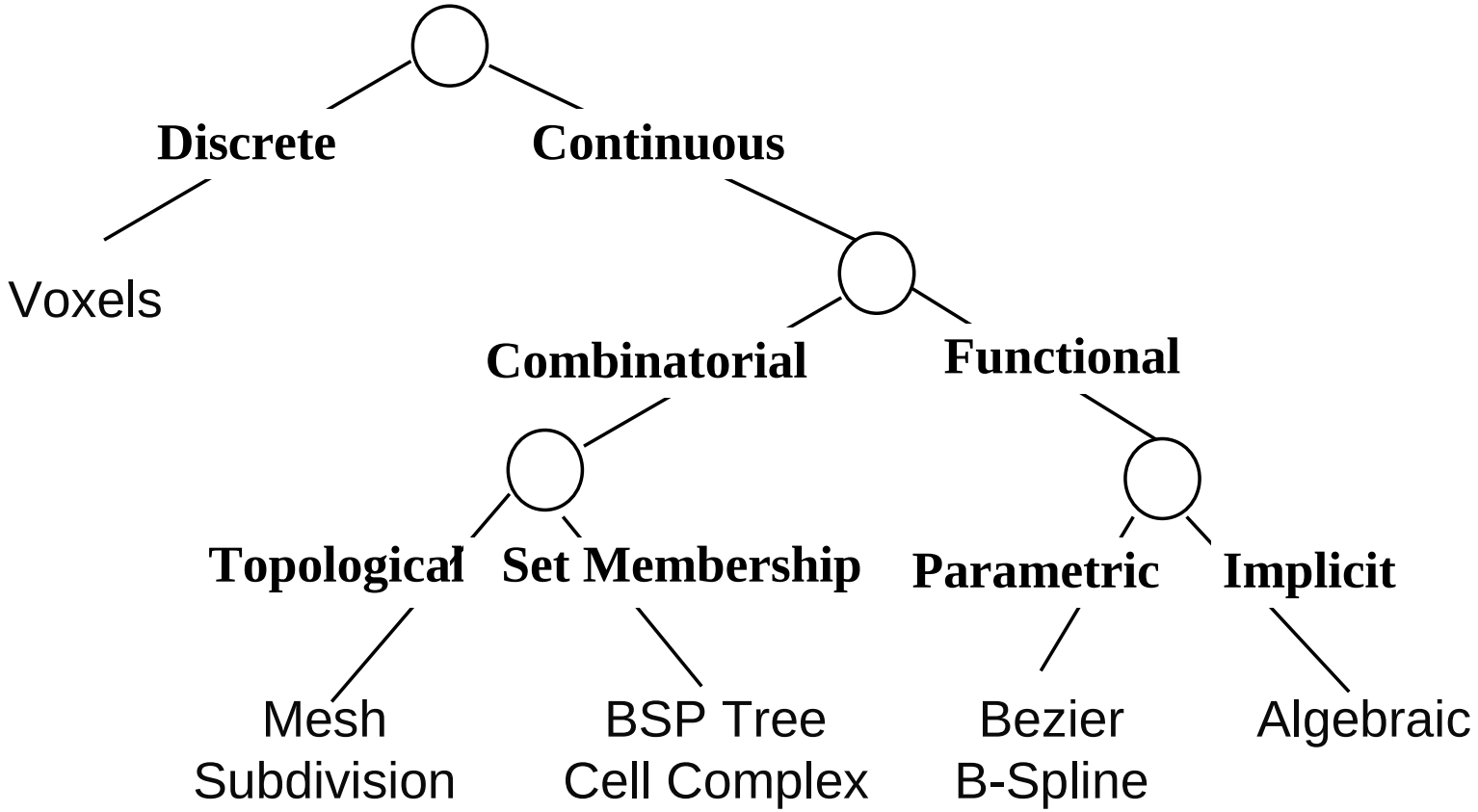
Cell Complex

- Arrangement of polyhedral cells with adjacent cells linked and solid cells labeled
  - e.g., adjacency graph of BSP leaf cells



Murali

Taxonomy of 3D Representations



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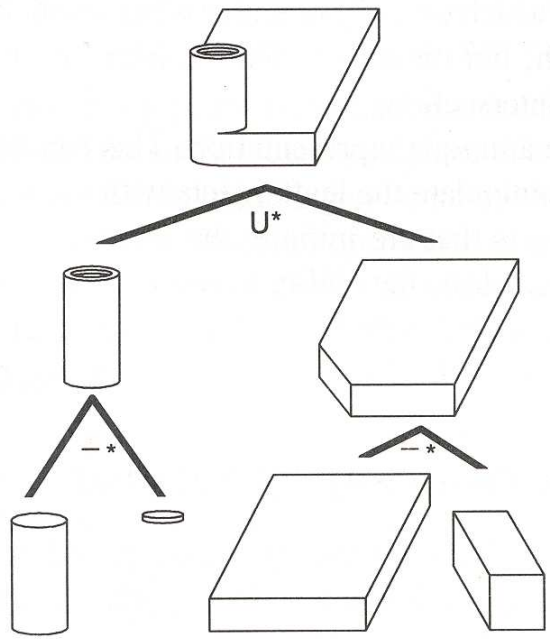
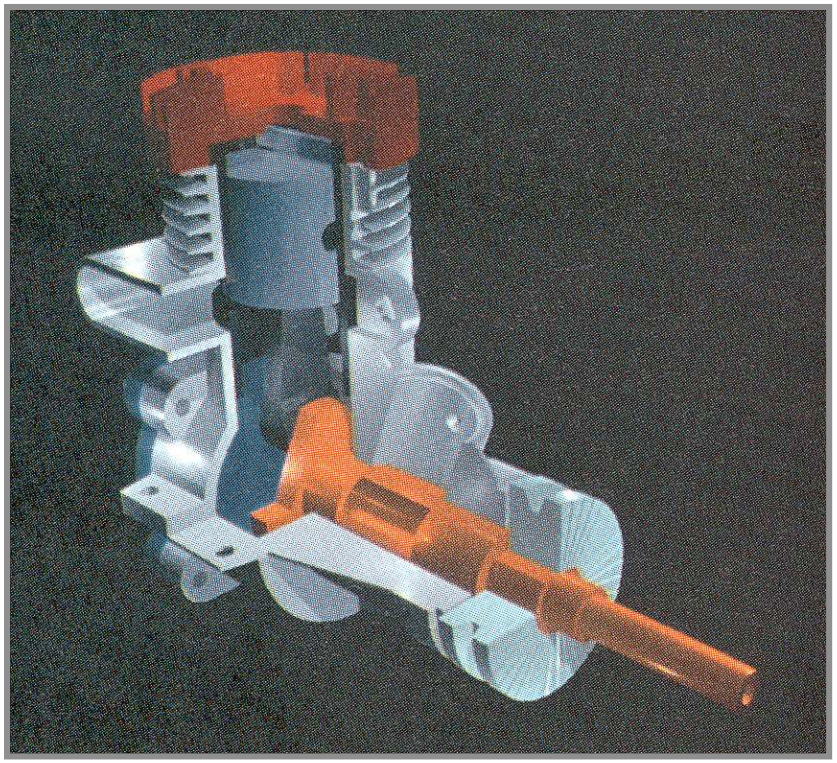
CSG

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



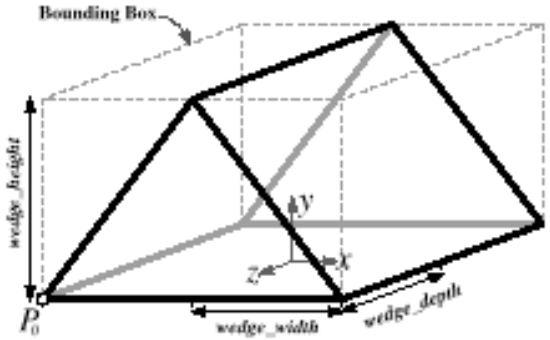
FvDFH Figure 12.27

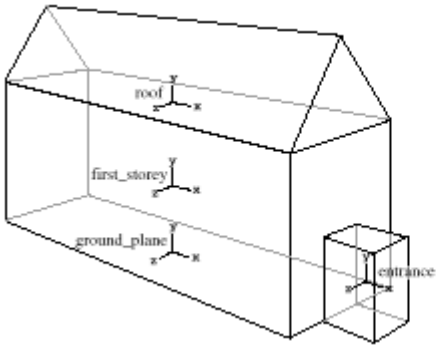


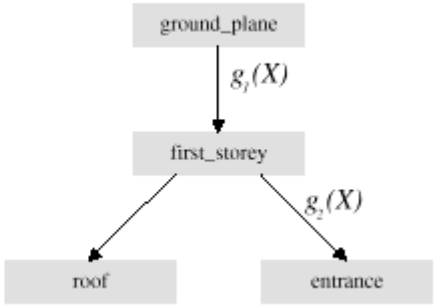
H&B Figure 9.9

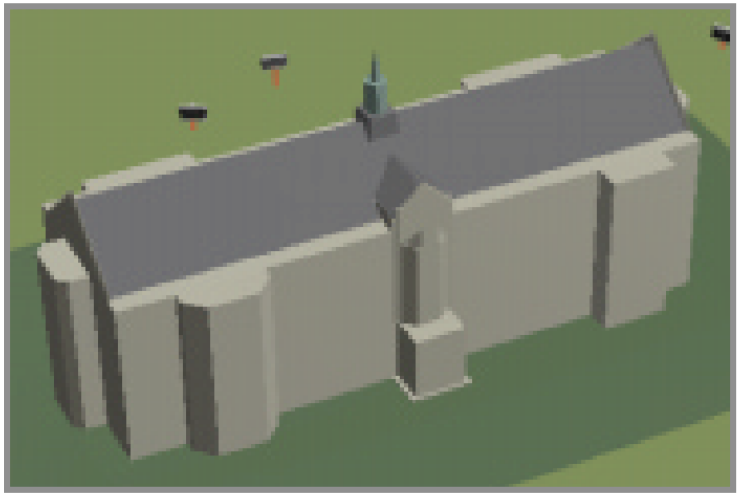
Constrained Blocks

- Set of simple shapes with geometric constraints





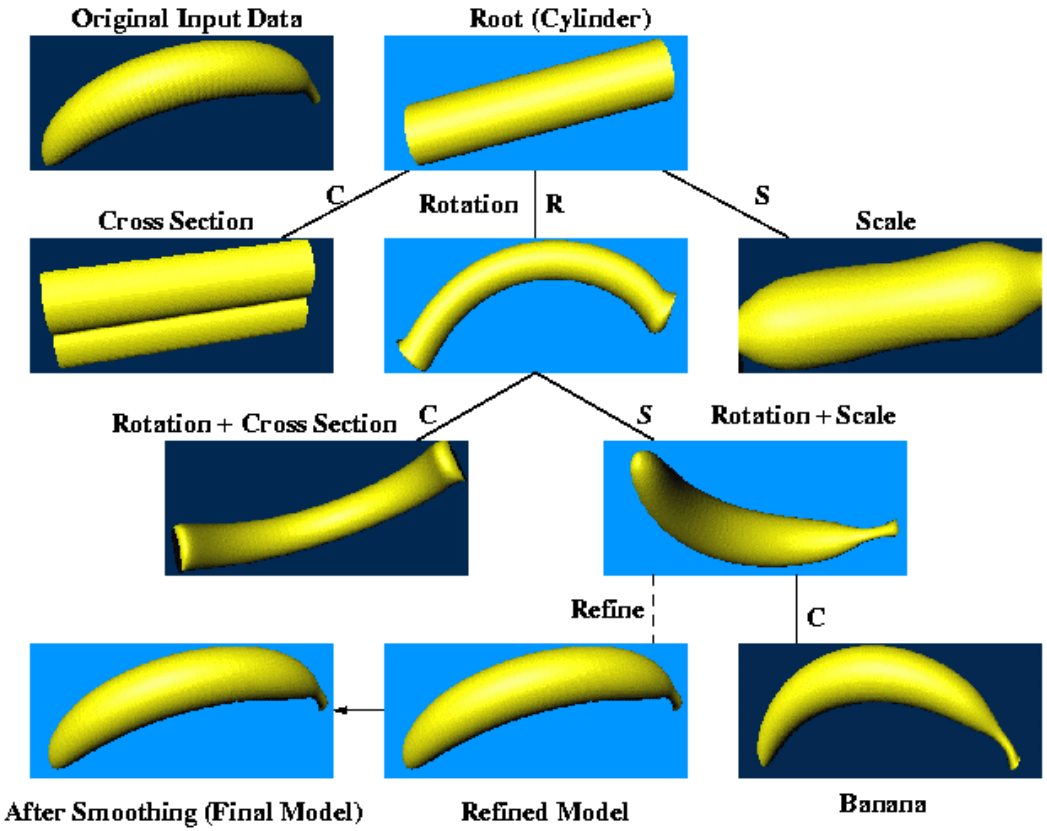




Debevec et al.

Generative Model

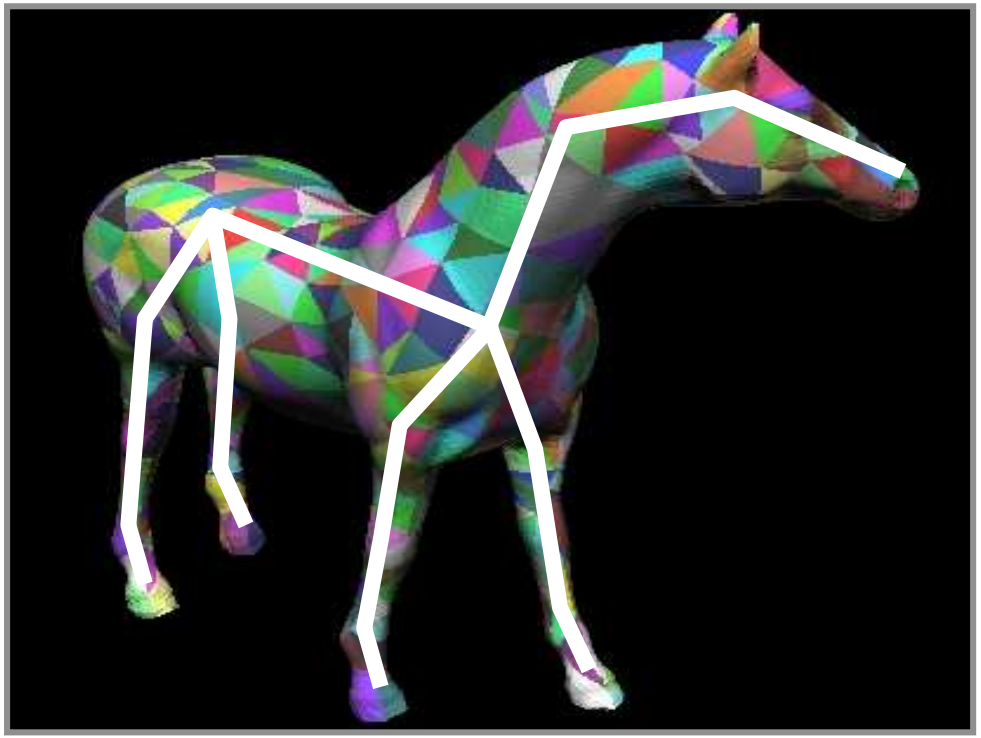
- Hierarchy of modifying curves



Ramamoorthy et al.

Skeleton

- Graph of curves with radii



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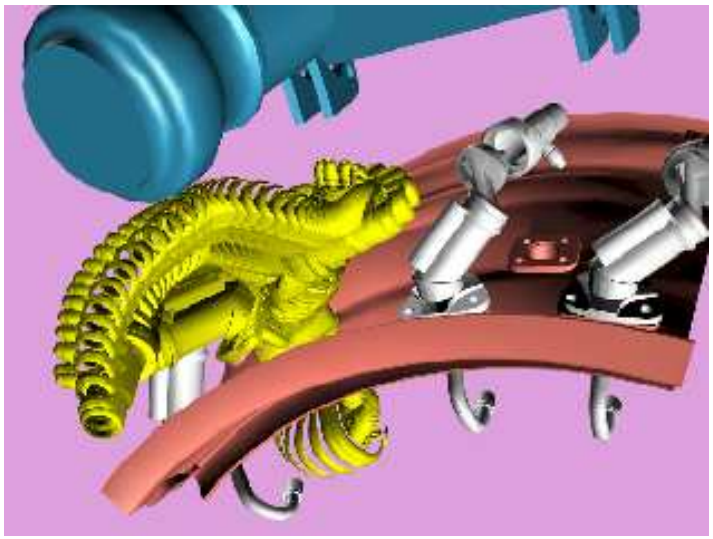
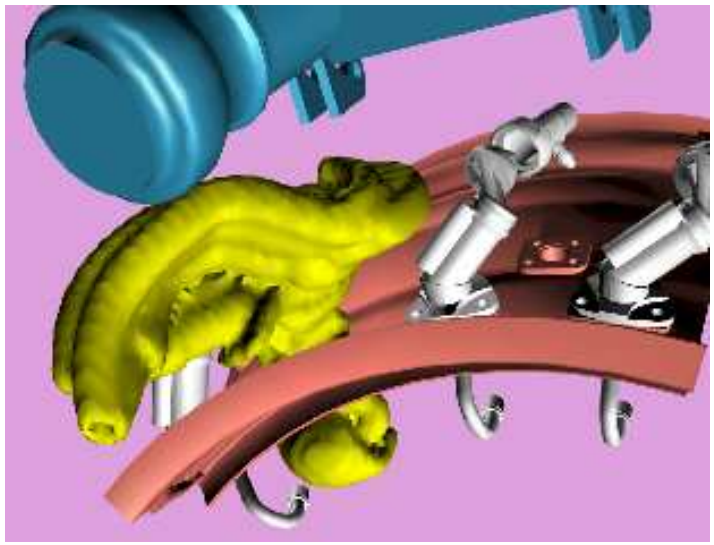
SGI

Sweep

- Surface swept by curve along trajectory

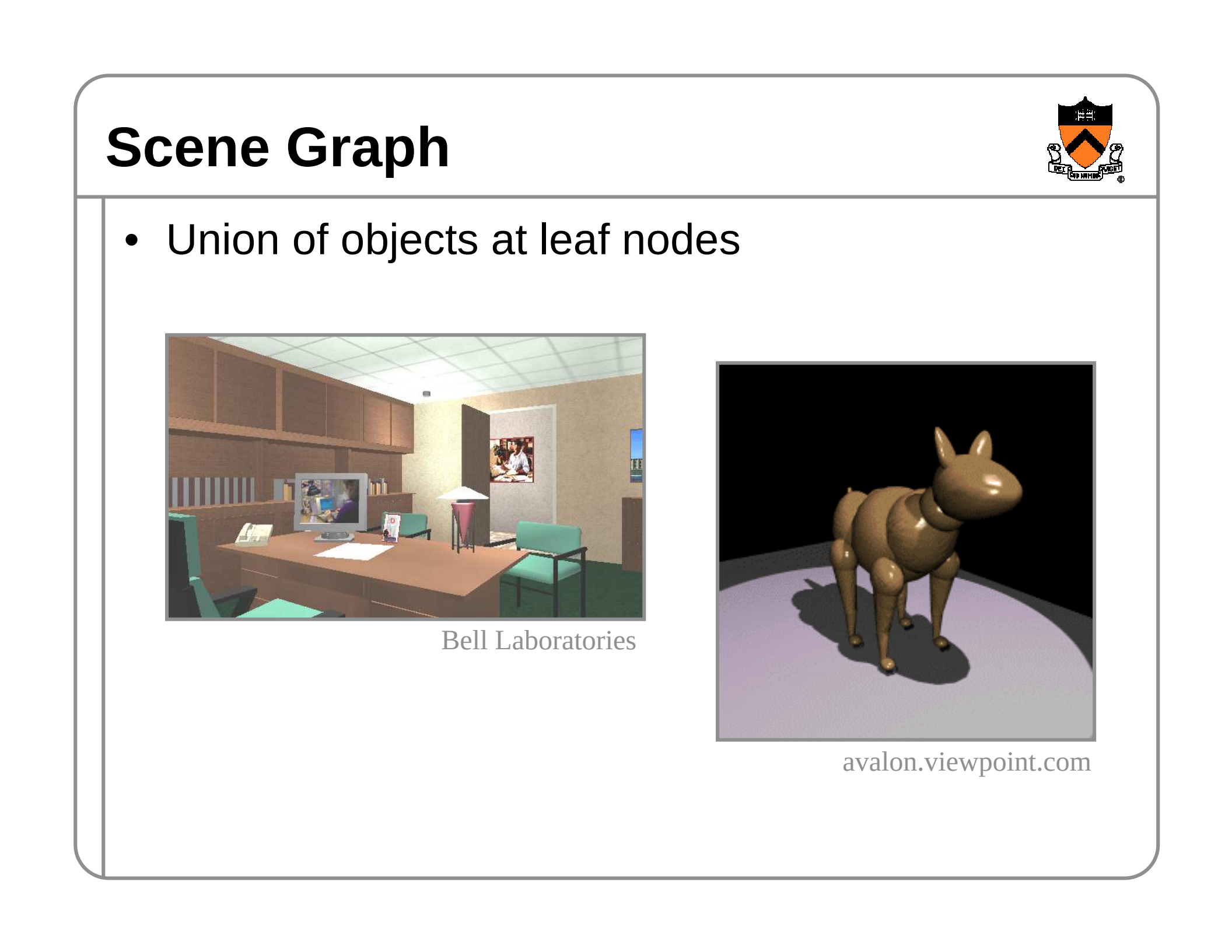


Removal Path



Sweep Model

Scene Graph

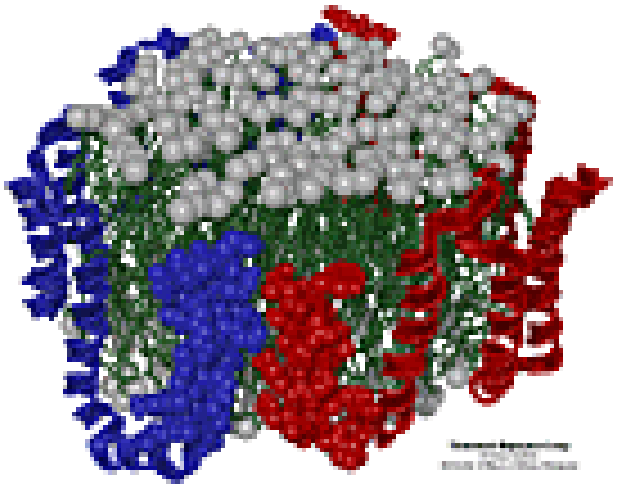


- Union of objects at leaf nodes

Bell Laboratories

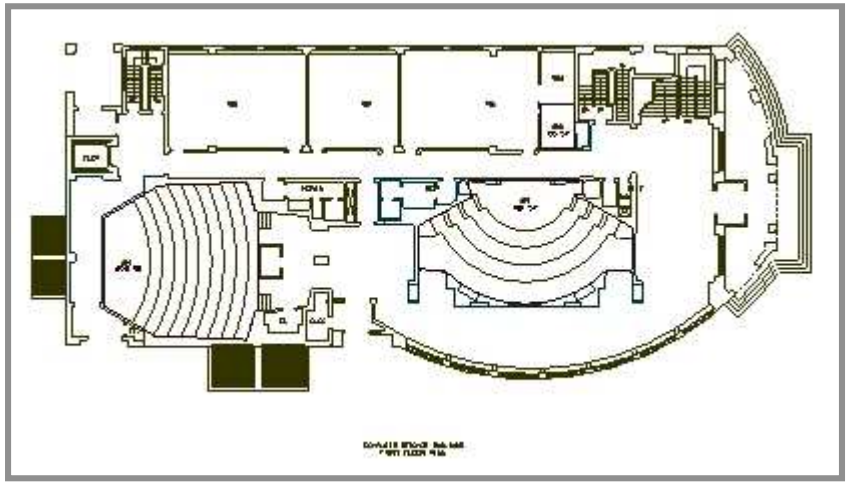
avalon.viewpoint.com

Others?



Apo A-1

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



Architectural Floorplan

(CS Building, Princeton University)

Summary

- Goals
  - Reconstruction
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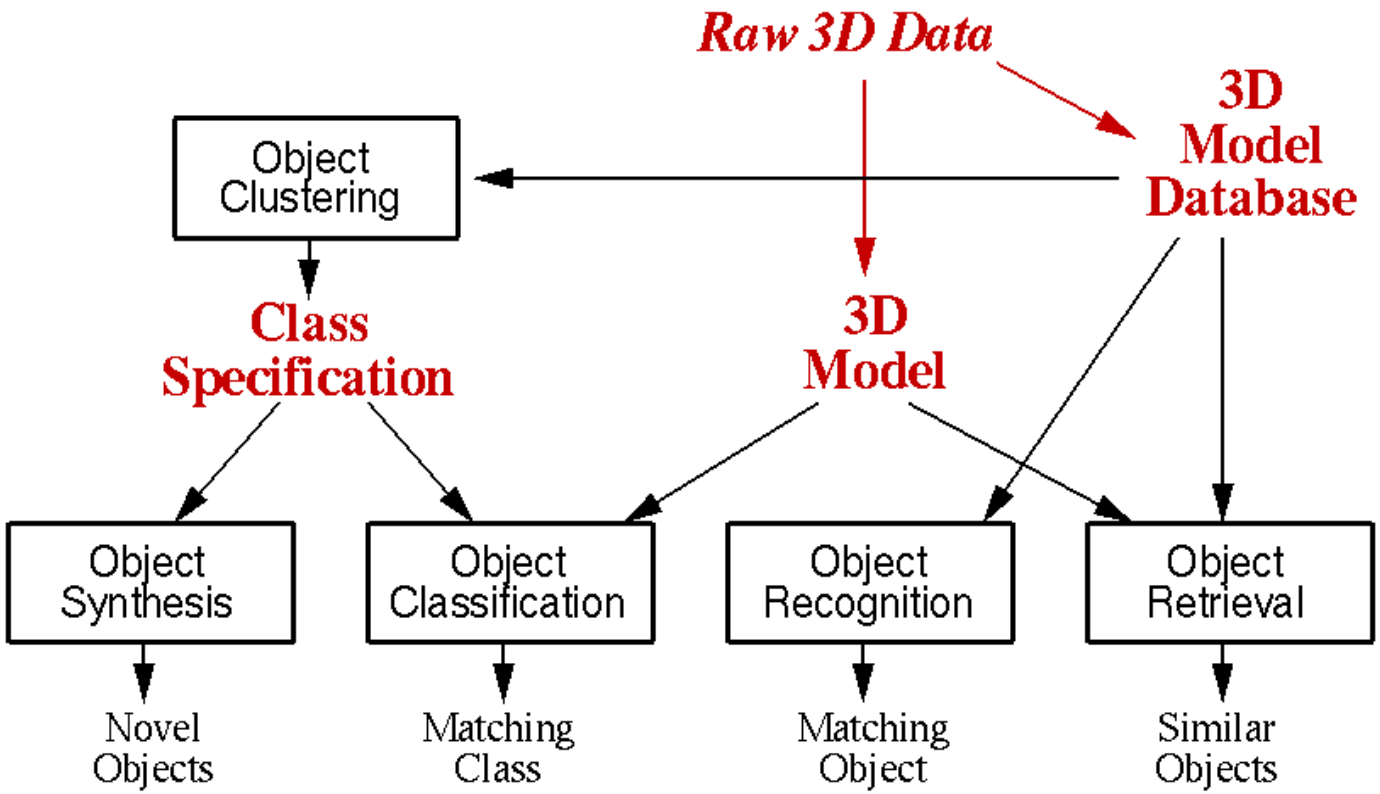
Summary



3D object representation is key!

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- Raw data
  - Point cloud
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  - Polygon soup
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