3D Object Representation

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How can this object be represented in a computer?
3D Objects

This one?

H&B Figure 10.46
3D Objects

This one?

H&B Figure 9.9
3D Objects

This one?
3D Object Representations

- **Raw data**
  - Point cloud
  - Range image
  - Polygon soup

- **Surfaces**
  - Mesh
  - Subdivision
  - Parametric
  - Implicit

- **Solids**
  - Voxels
  - BSP tree
  - CSG
  - Sweep

- **High-level structures**
  - Scene graph
  - Skeleton
  - Application specific
Point Clouds

- Unstructured set of 3D point samples
  - Acquired from random sampling, particle system implementations, etc.

Hoppe

Hoppe
Range Images

- An image storing depth instead of / as well as color
  - Acquired from 3D scanners
Polygon Soups

- Unstructured set of polygons
  - Created with interactive modeling systems, combining range images, etc.
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(Manifold) Meshes

- Connected set of polygons (usually triangles)
Subdivision Surfaces

• Coarse mesh & subdivision rule
  ◦ Define smooth surface as limit of sequence of refinements
Parametric Surfaces

- Tensor product spline patches
  - Careful use of constraints to maintain continuity

FvDFH Figure 11.44
Implicit Surfaces

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

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

FvDFH Figure 12.20

Stanford Graphics Laboratory
BSP Trees

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

[Diagram of BSP Tree with labeled objects and regions]

Object

Binary Spatial Partition

Binary Tree
Constructive Solid Geometry (CSG)

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

FvDFH Figure 12.27

H&B Figure 9.9
Sweep Surfaces

- Solid swept by curve along trajectory

Stephen Chenney
U Wisconsin
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Scene Graphs

- Union of objects at leaf nodes
Skeletons

• Graph of curves with radii
Application Specific

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

Architectural Floorplan
Surfaces

• What makes a good surface representation?
  ◦ Concise
  ◦ Local support
  ◦ Affine invariant
  ◦ Arbitrary topology
  ◦ Guaranteed smoothness
  ◦ Natural parameterization
  ◦ Efficient display
  ◦ Efficient intersections

H&B Figure 10.46
Surfaces

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Not Local Support
Surfaces

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  - Local support
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Applying an affine transformation to the surface does not fundamentally change its representation.
Surfaces

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Topological Genus
Equivalences
Surfaces

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A Parameterization (not necessarily natural)
Surfaces

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