Review of Basics of 3D Object Representation

Connelly Barnes

CS 6501: Large-scale data-driven graphics and vision

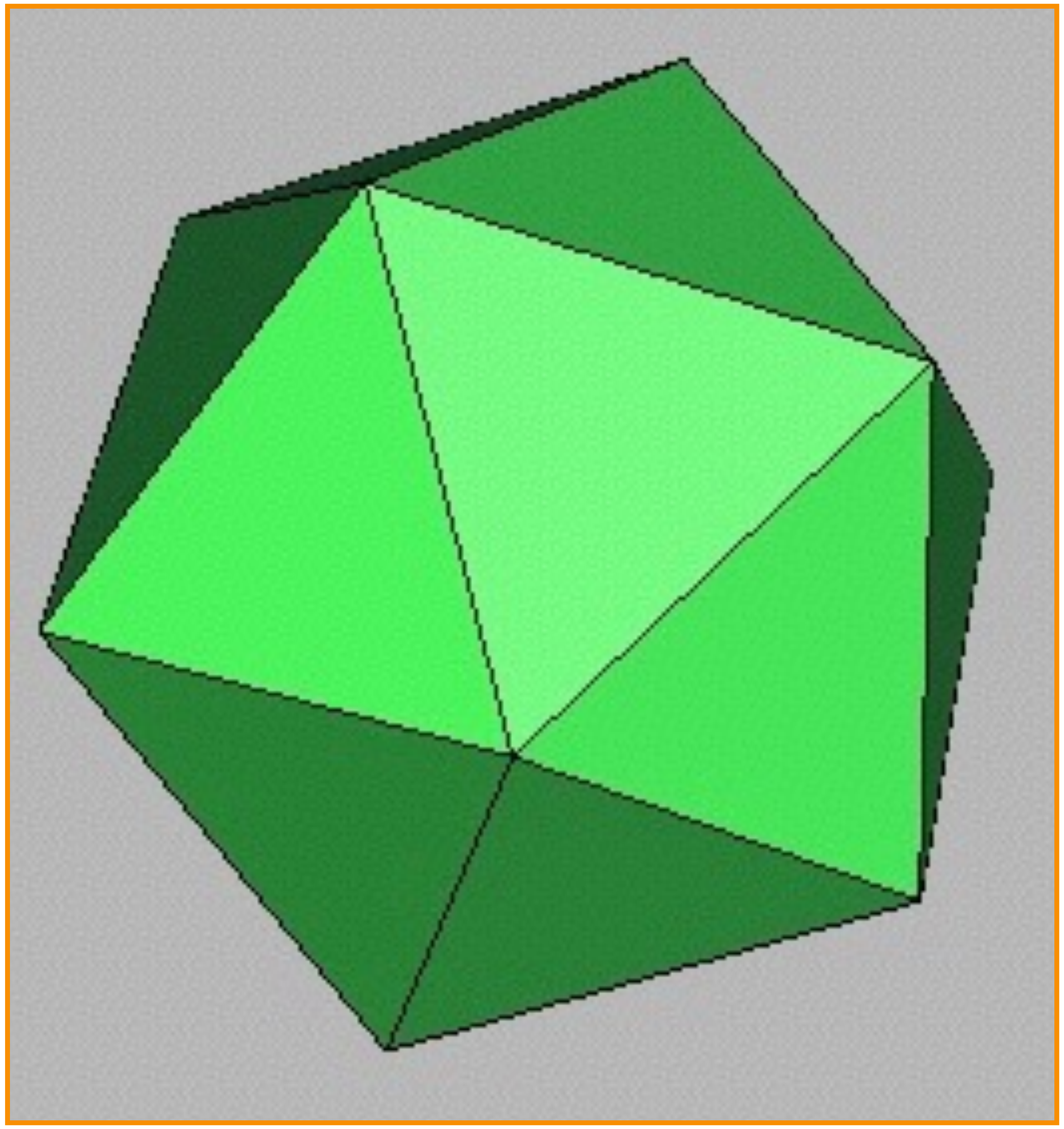
Acknowledgment: slides by Jason Lawrence, Misha Kazhdan, Allison Klein, Tom Funkhouser, Adam Finkelstein and David Dobkin

3D Object Representation

- How do we ...
  - Represent 3D objects in a computer?
  - Construct such representations quickly and/or automatically with a computer?
  - Manipulate 3D objects with a computer?

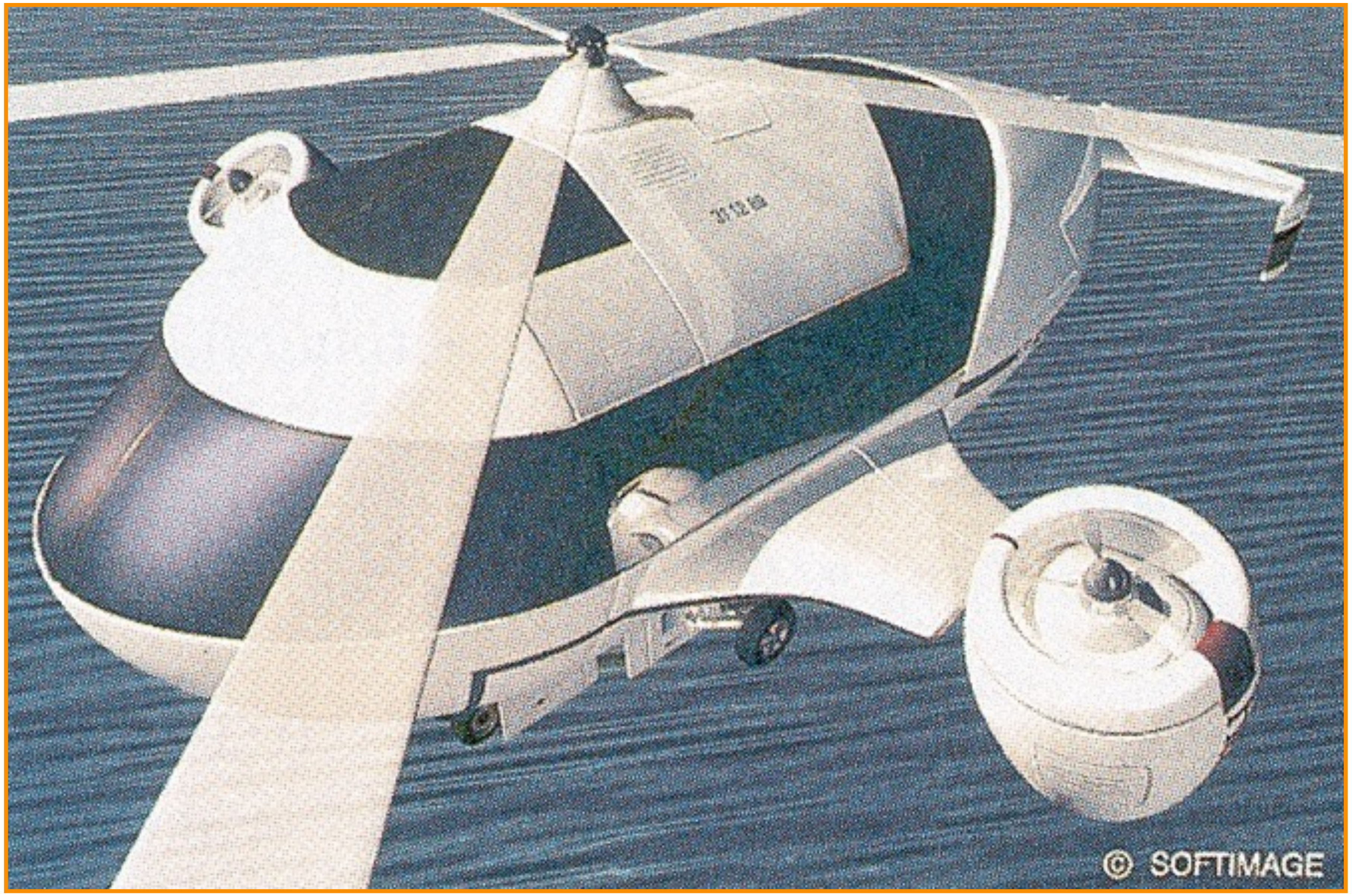
Different methods for different object representations

3D Objects



How can this object be represented in a computer?

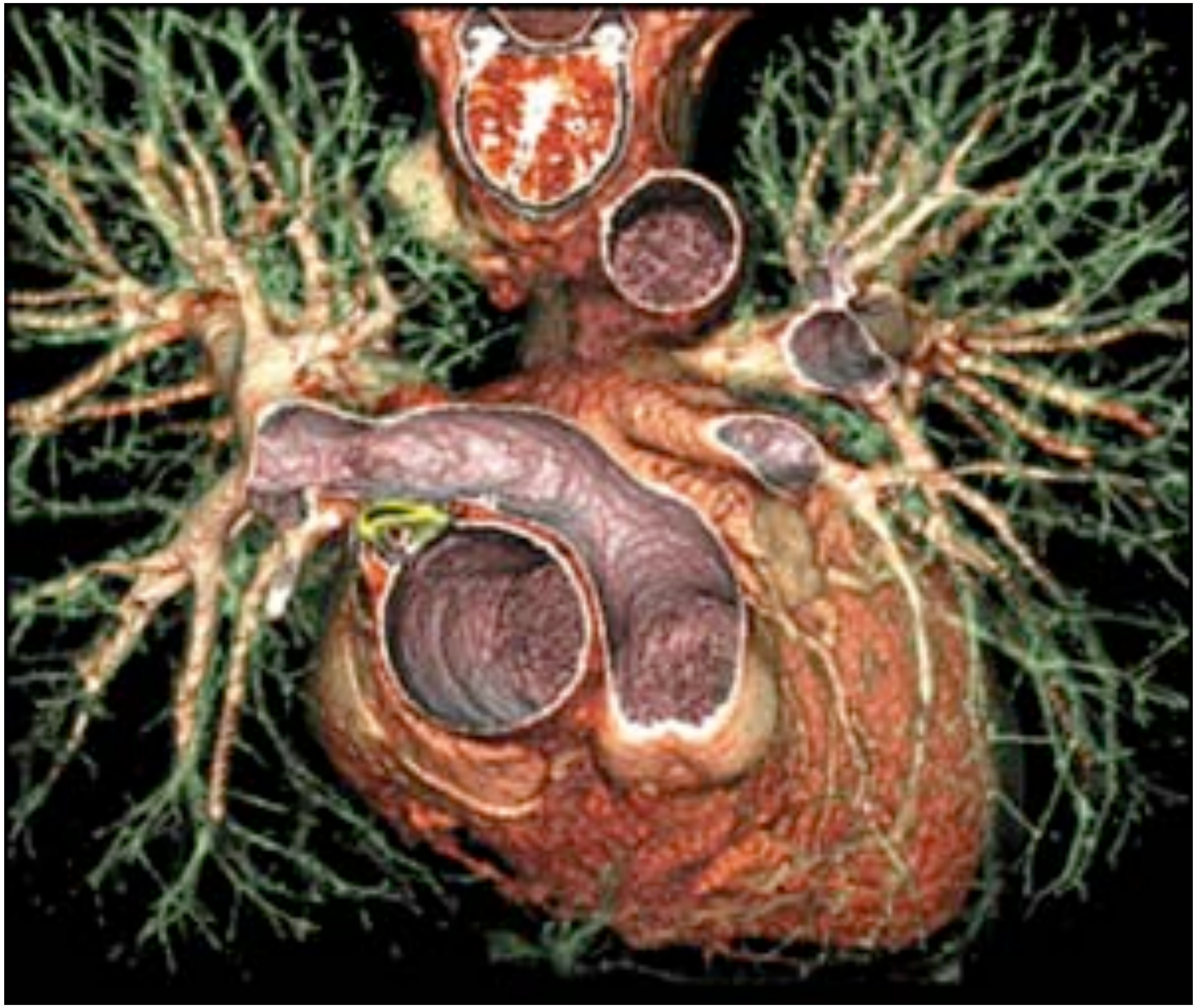
3D Objects



H&B Figure 10.46

This one?

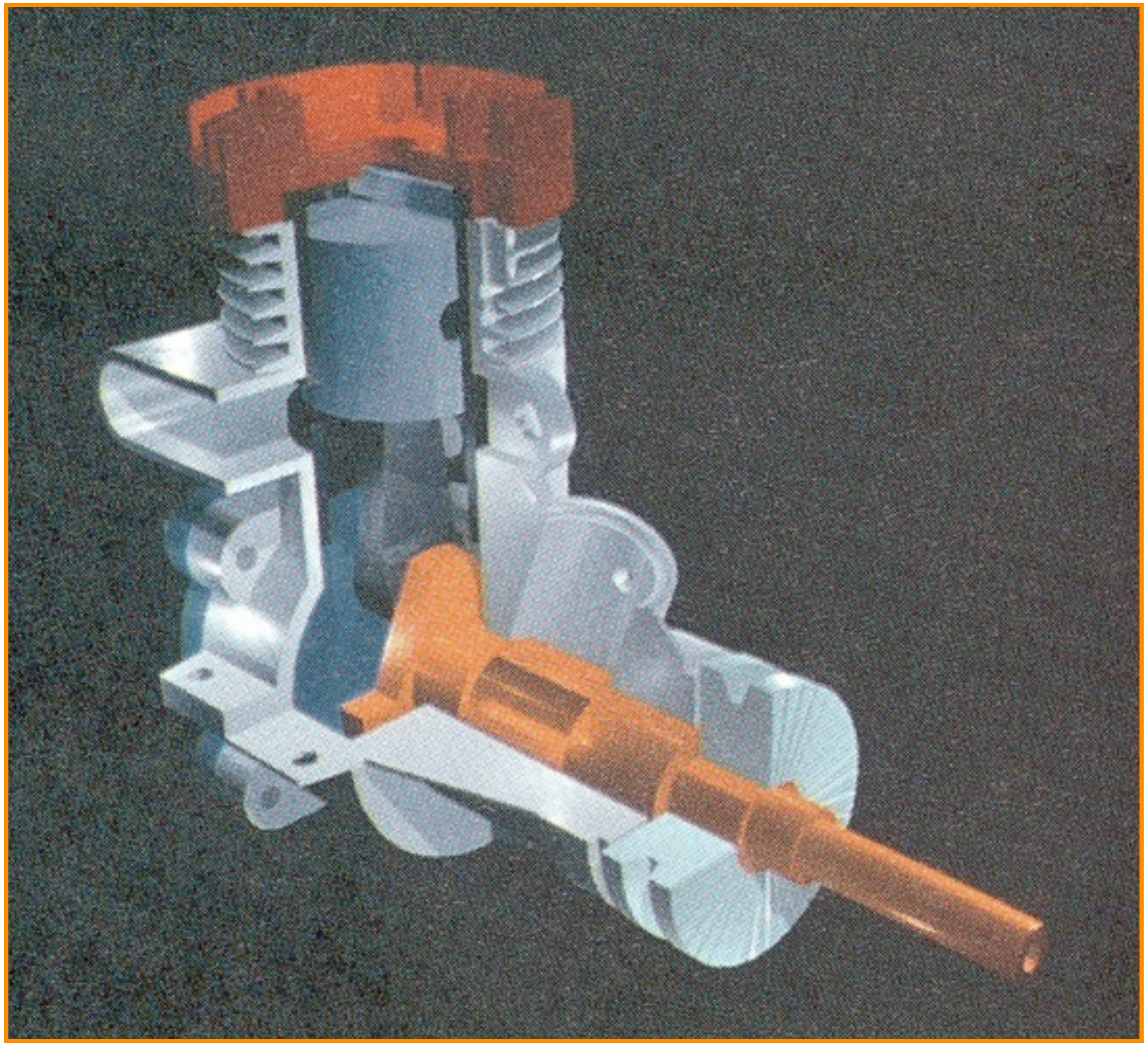
3D Objects



Imaging Economics

How about this one?

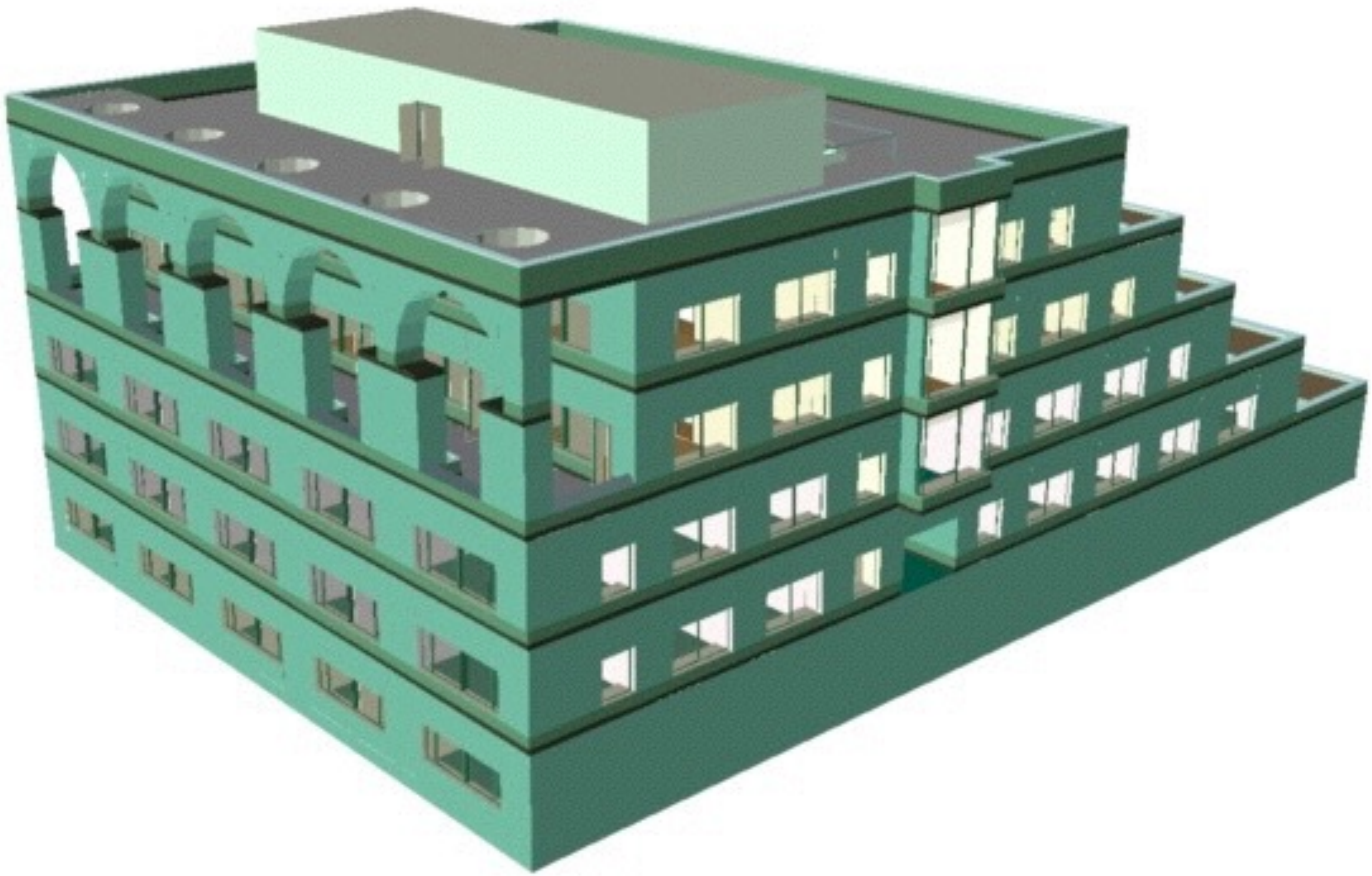
3D Objects



H&B Figure 9.9

This one?

3D Objects



This one?

Representations of Geometry

- 3D Representations provide the foundations for
  - **o** Computer Graphics
  - **o** Computer-Aided Geometric Design
  - **o** Visualization
  - **o** Robotics

- They are languages for describing geometry

  data structures **algorithms**

- Data structures determine algorithms!

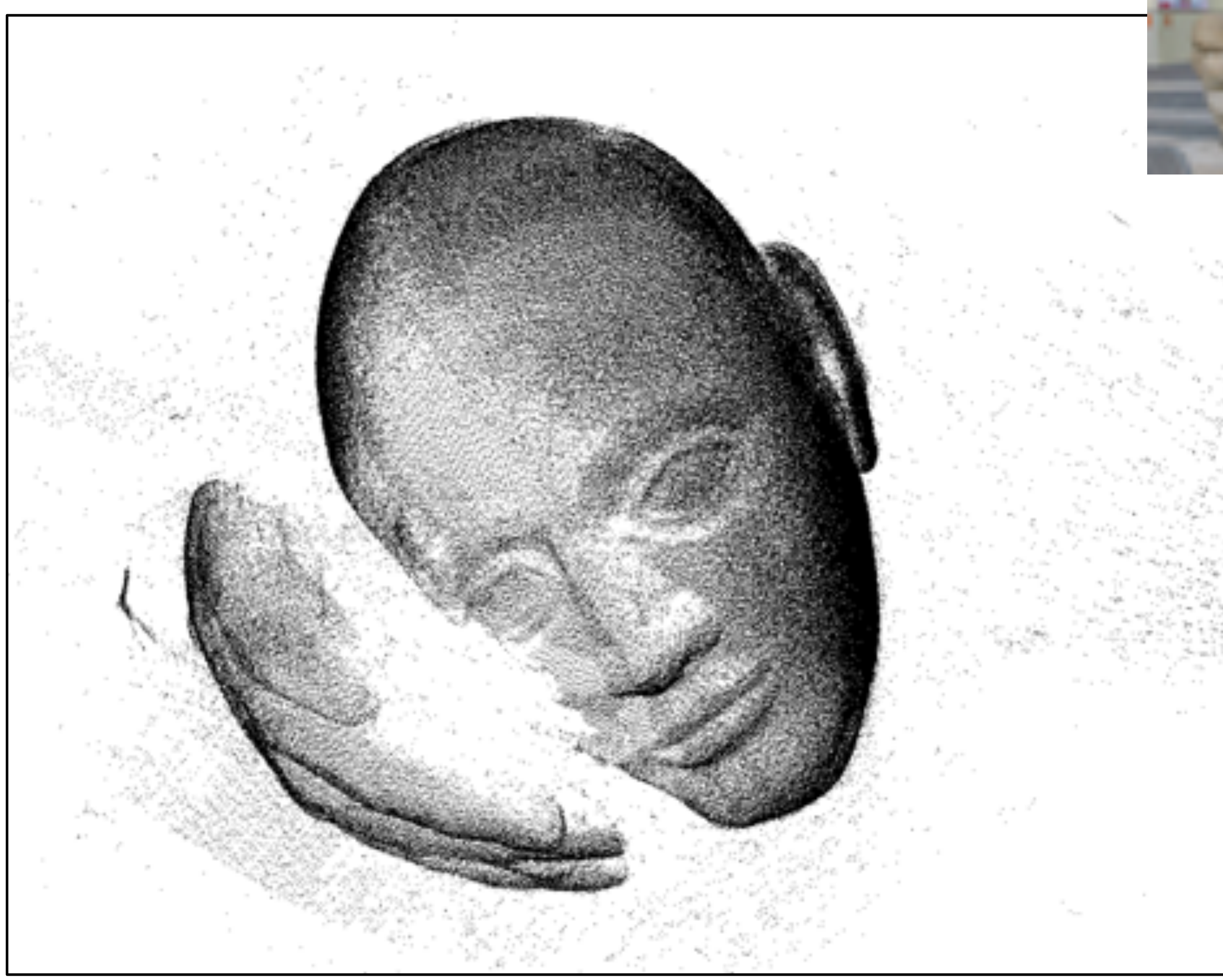
3D Object Representations

- Raw data
  - Point cloud
  - Range image
  - Polygon soup
- Surfaces
  - Mesh
  - Parametric
  - Implicit
- Solids
  - Voxels

See slides from the graphics class for more!

Point Cloud

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



Hoppe

Czech Academy of Sciences

Point Cloud

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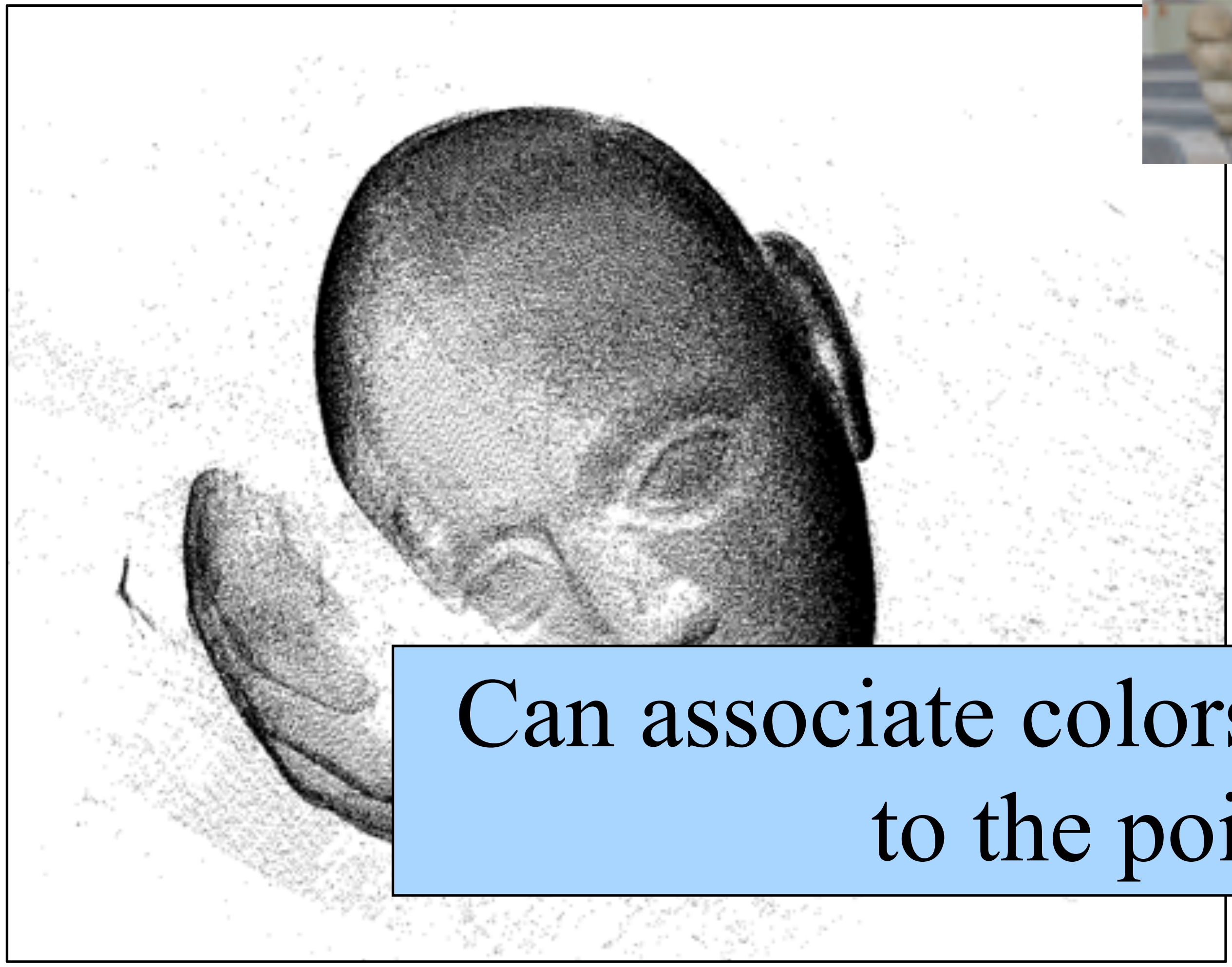
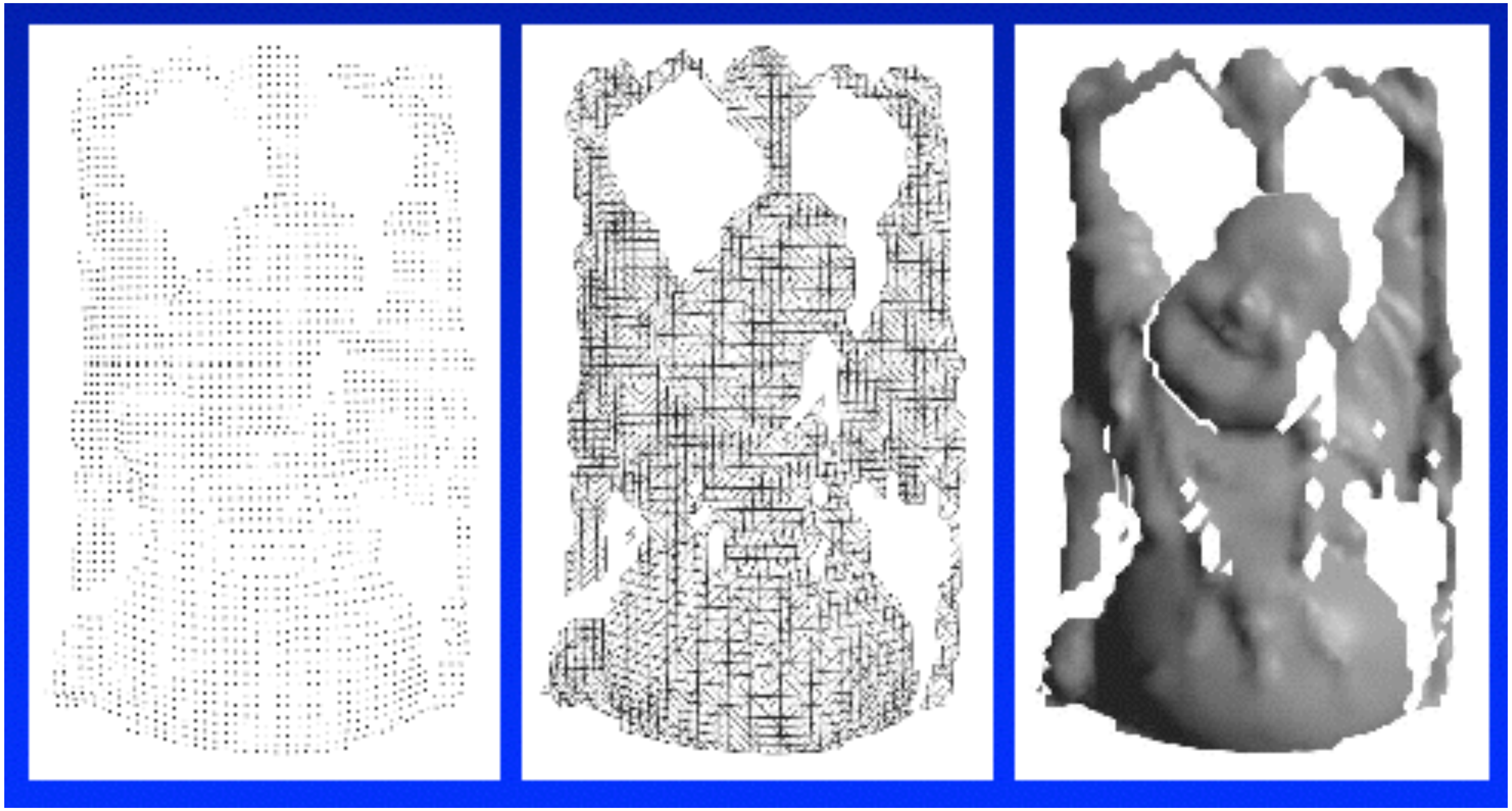


Can associate colors/normals/etc. to the points

Range Image

- An image storing depth instead of color
  - Acquired from range scanners — e.g. Microsoft Kinect

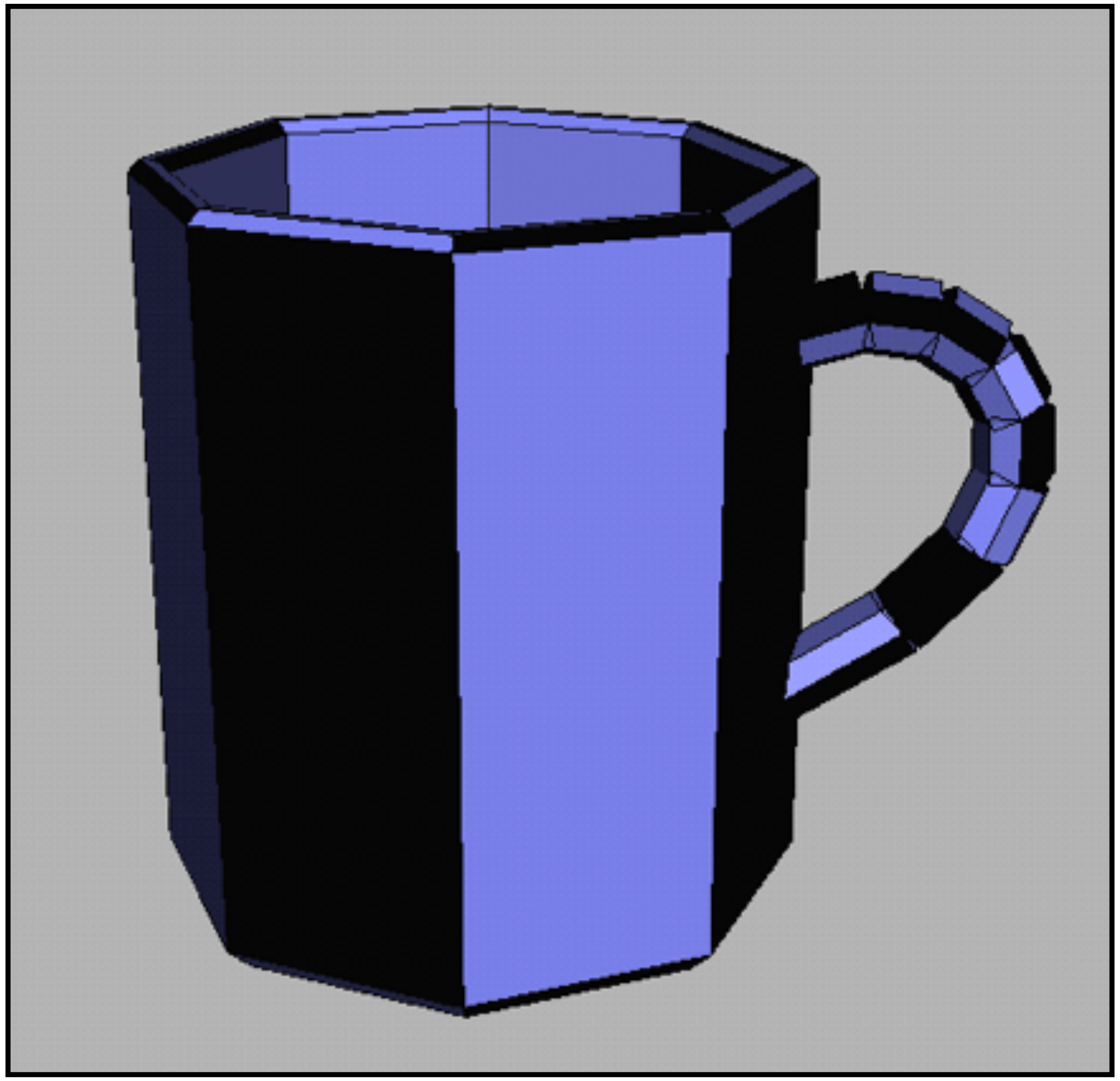


Range Image Tesselation Range Surface

Brian Curless
SIGGRAPH 99
Course #4 Notes

Polygon Soup

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



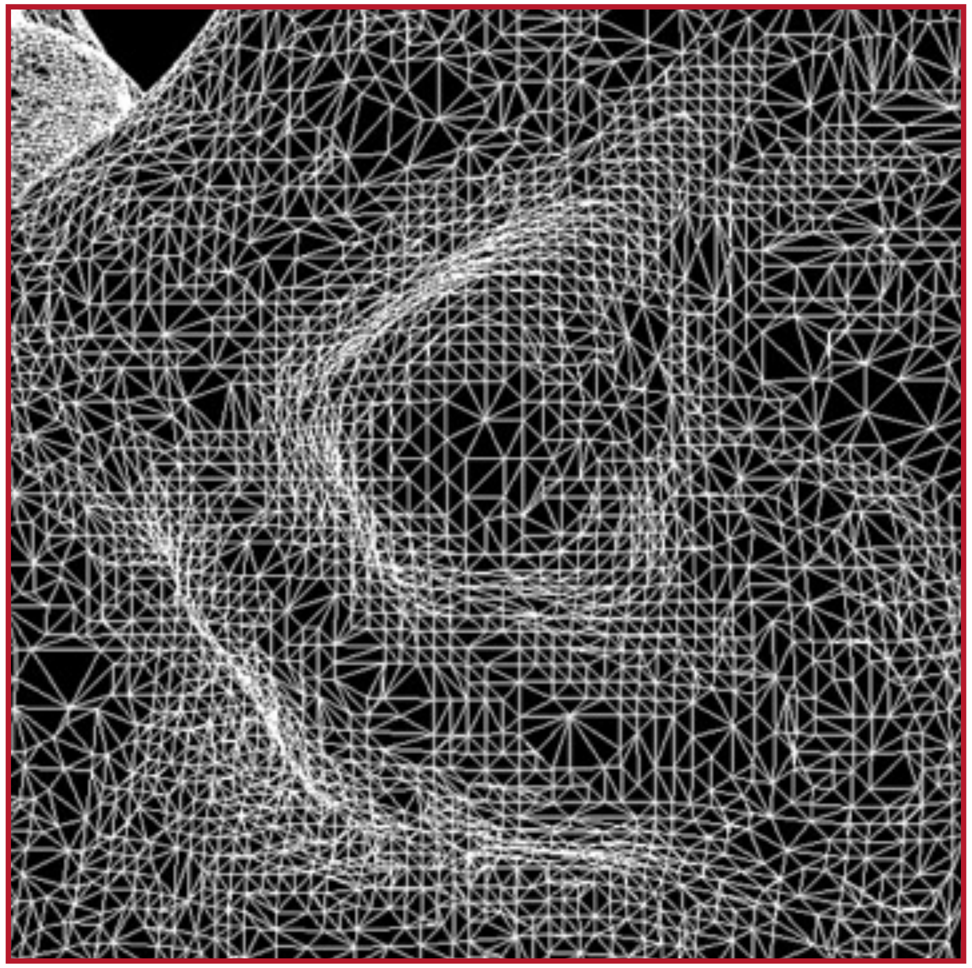
Larson

3D Object Representations

- Raw data
  - Point cloud
  - Range image
  - Polygon soup
- Surfaces
  - Mesh
  - Parametric
  - Implicit
- Solids
  - Voxels

Mesh

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



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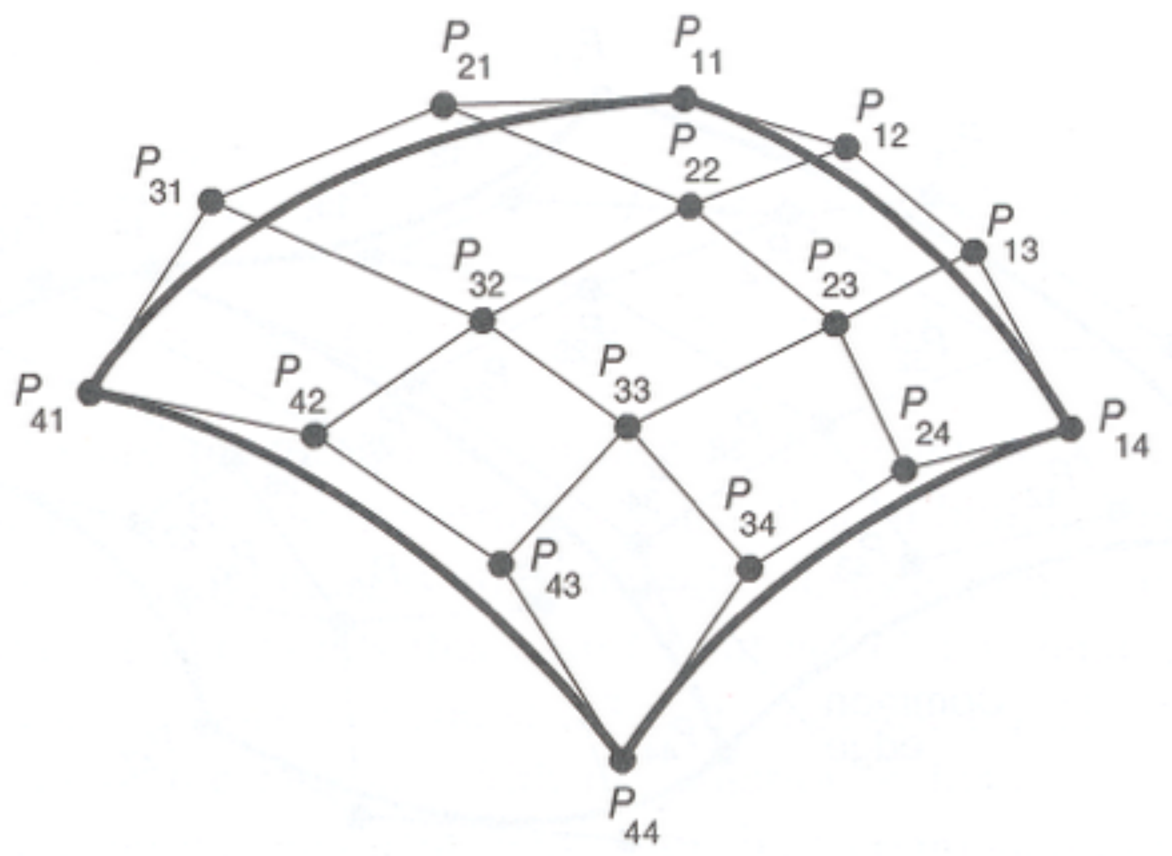
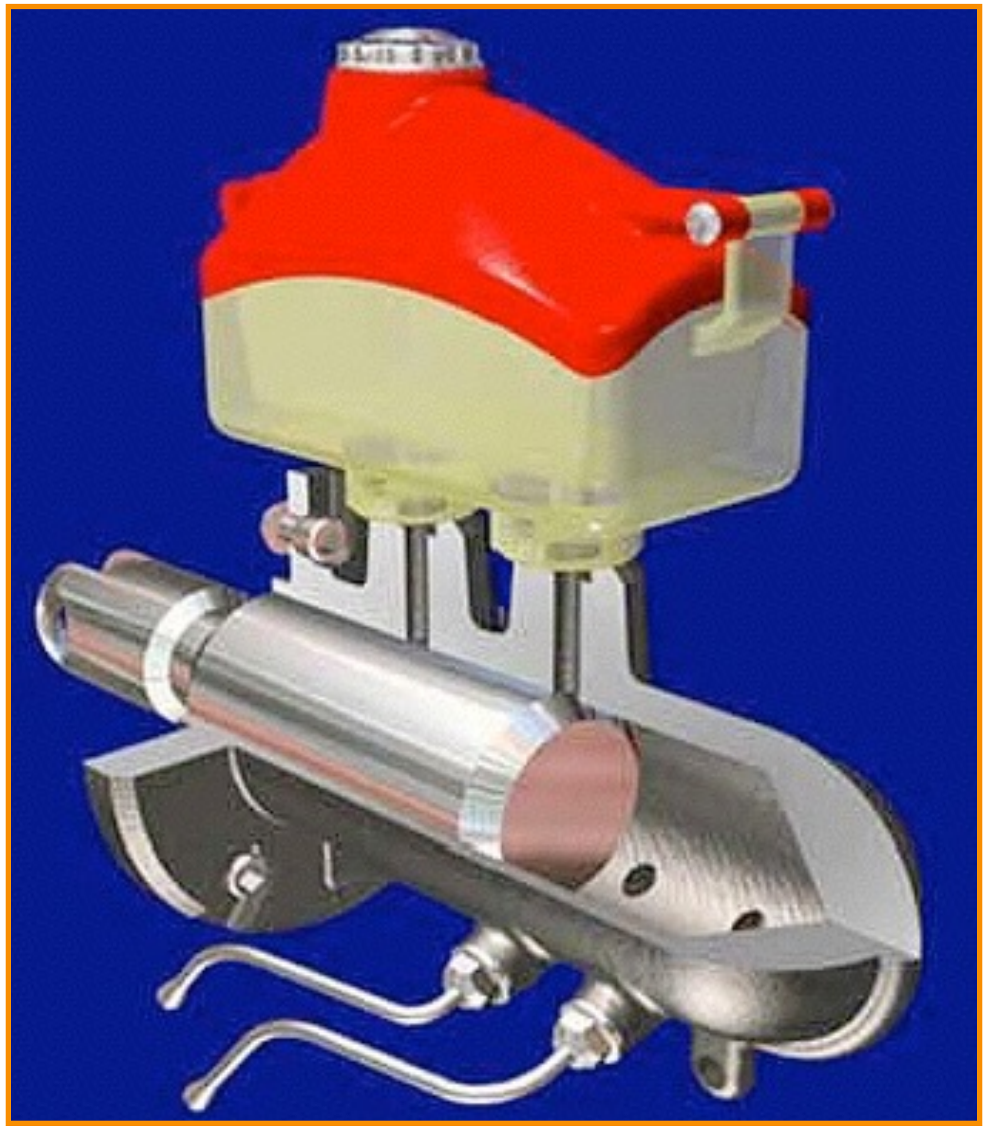
Parametric Surface

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

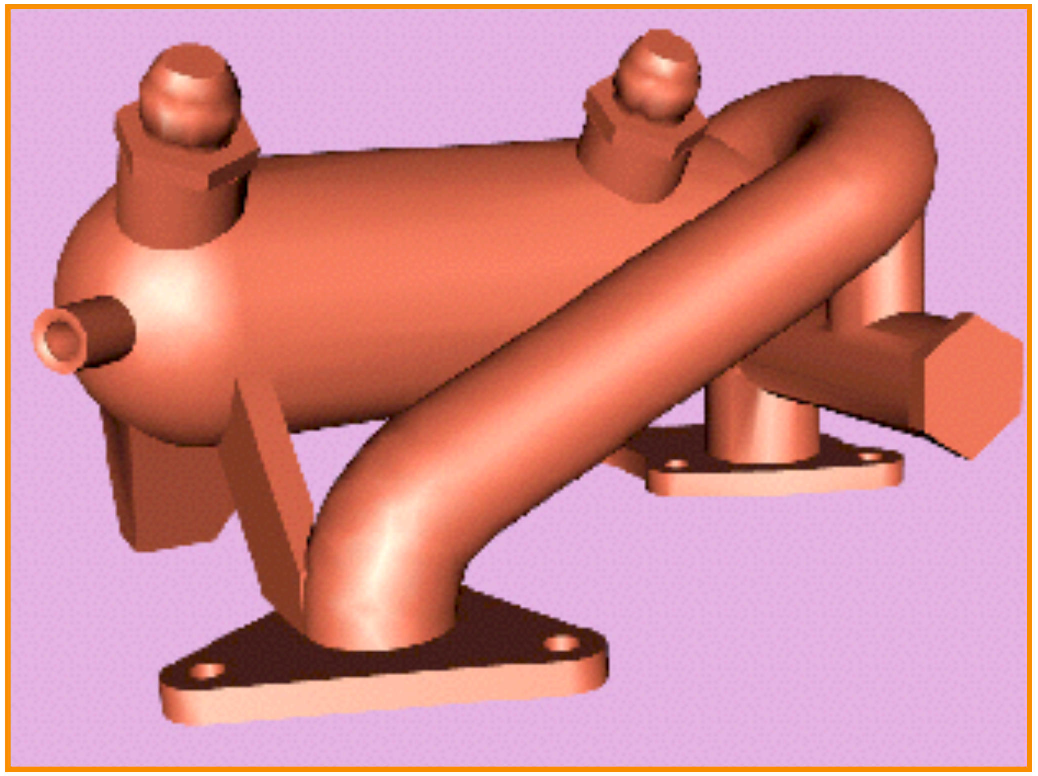


FvDFH Figure 11.44

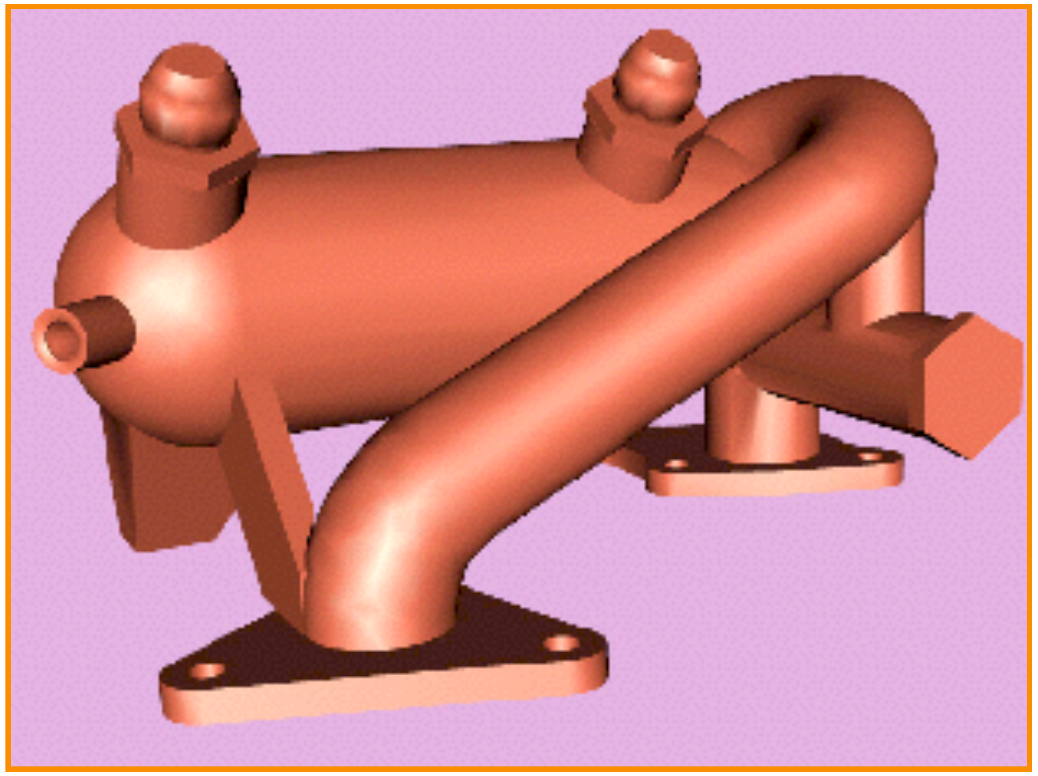


Implicit Surface

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



Polygonal Model



Implicit Model

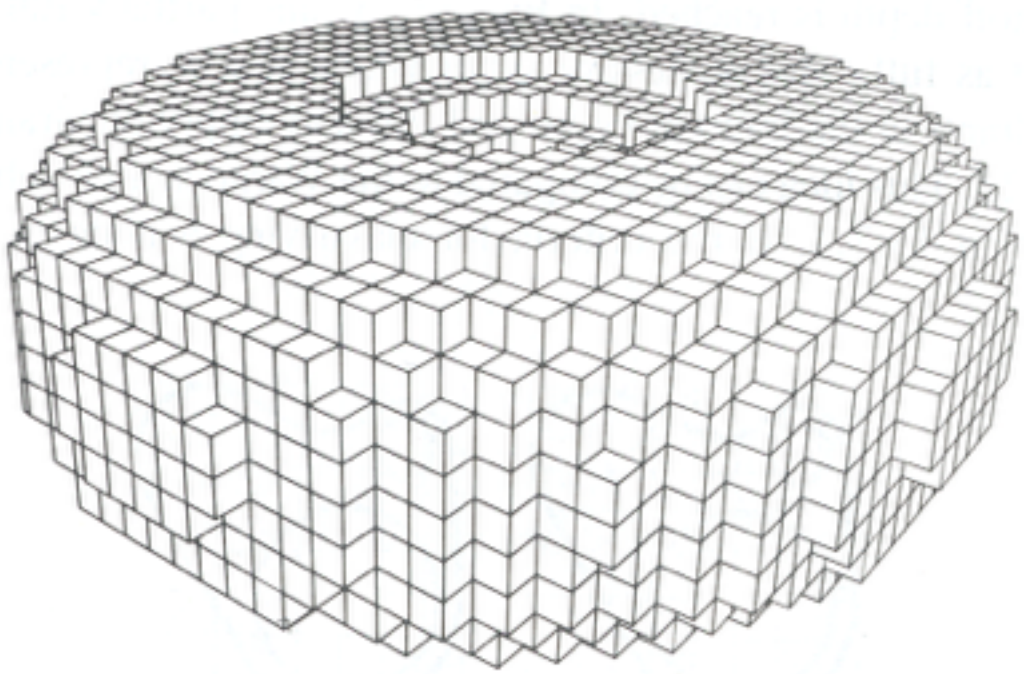
Bill Lorensen
SIGGRAPH 99
Course #4 Notes

3D Object Representations

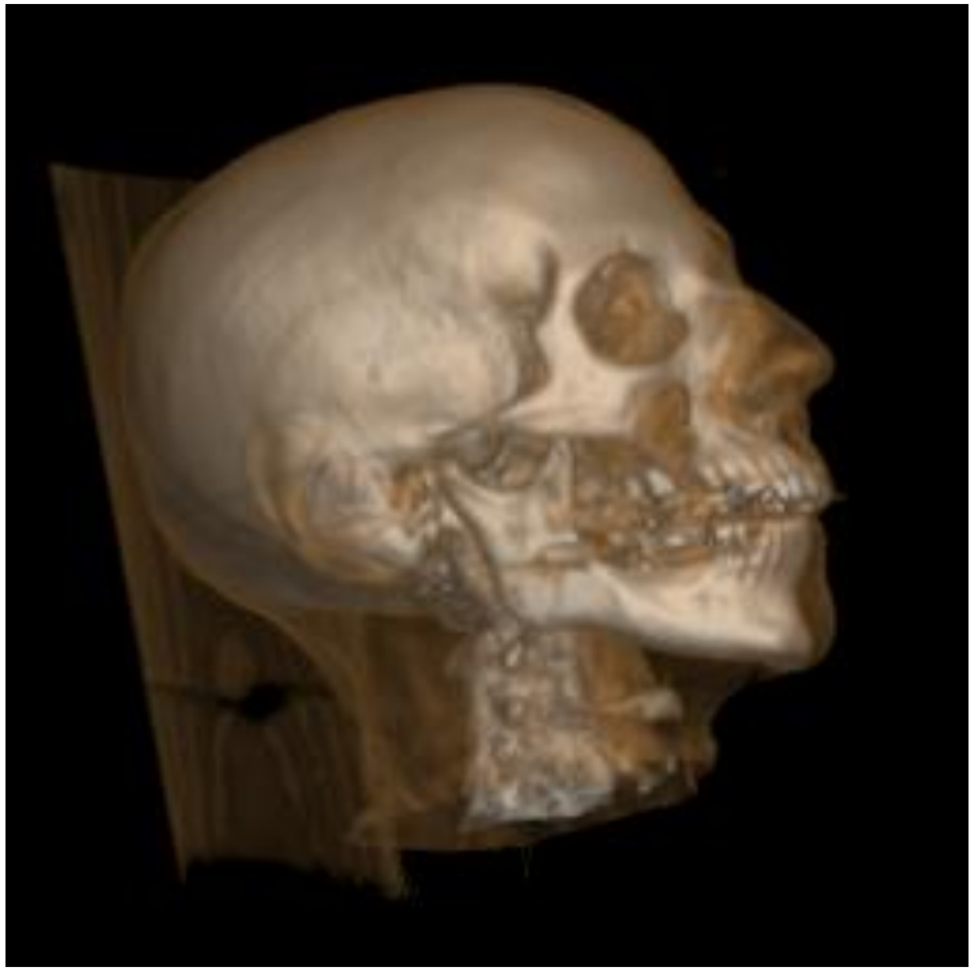
- Raw data
  - Point cloud
  - Range image
  - Polygon soup
- Surfaces
  - Mesh
  - Subdivision
  - Parametric
  - Implicit
- Solids
  - Voxels

Voxels

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



FvDFH Figure 12.20



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Equivalence of Representations

- Thesis:
  - Each fundamental 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:
  - All computers today are Turing-equivalent, but we still have many different processors

Computational Differences

- Efficiency
  - Combinatorial complexity
  - Space/time trade-offs
  - Numerical accuracy/stability
- Simplicity
  - Ease of acquisition
  - Hardware acceleration
- Usability