

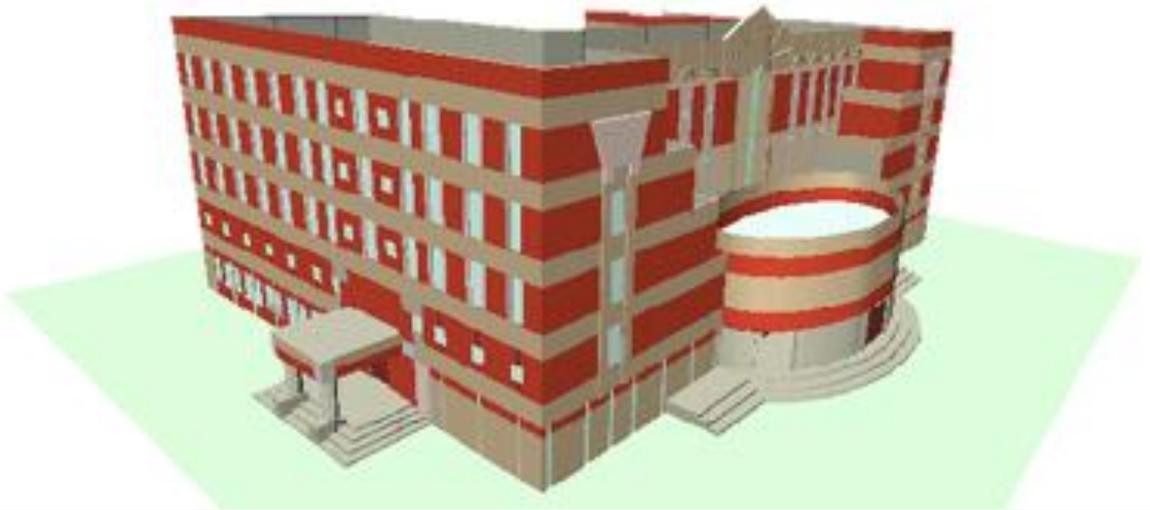
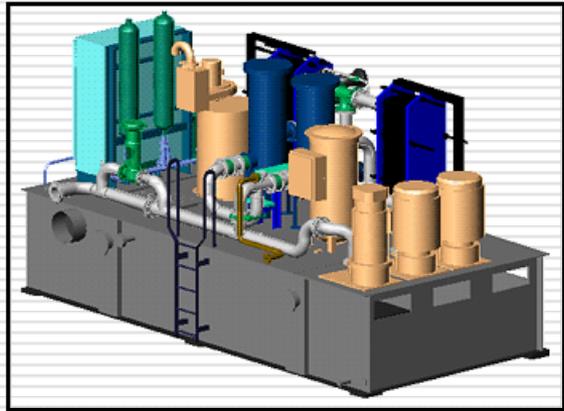
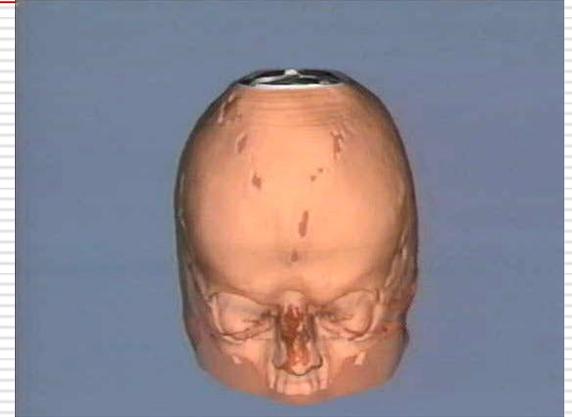
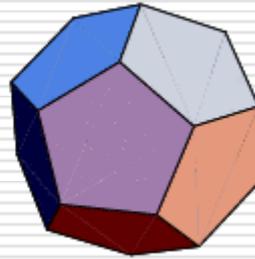
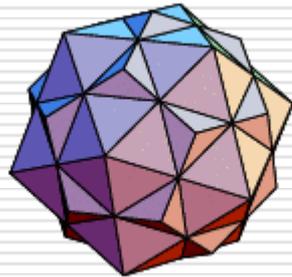
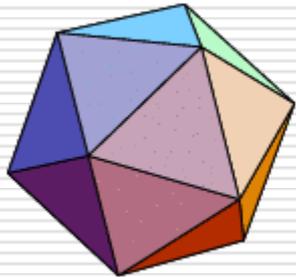
Geometric Modeling

Bing-Yu Chen
National Taiwan University
The University of Tokyo

3D Object Representations

- What are 3D objects?
 - The Graphics Process
 - 3D Object Representations
 - Raw Data
 - Surface Representations
 - Solid Modeling
 - High-level Structures
 - Procedural Modeling
-

What are 3D Objects ?



The Utah Teapot



http://en.wikipedia.org/wiki/Utah_teapot
<http://www.sjbaker.org/teapot/>

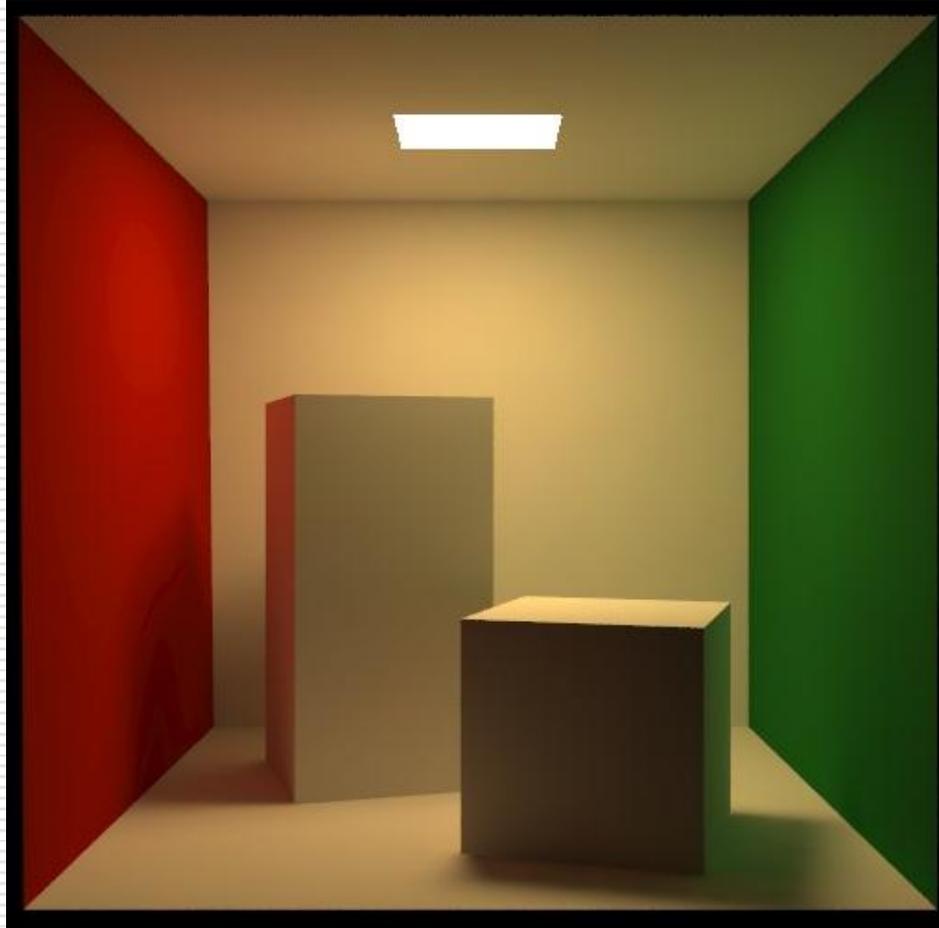
The Stanford Bunny



http://en.wikipedia.org/wiki/Stanford_Bunny

<http://www.gvu.gatech.edu/people/faculty/greg.turk/bunny/bunny.html>

The Cornell Box



http://en.wikipedia.org/wiki/Cornell_Box

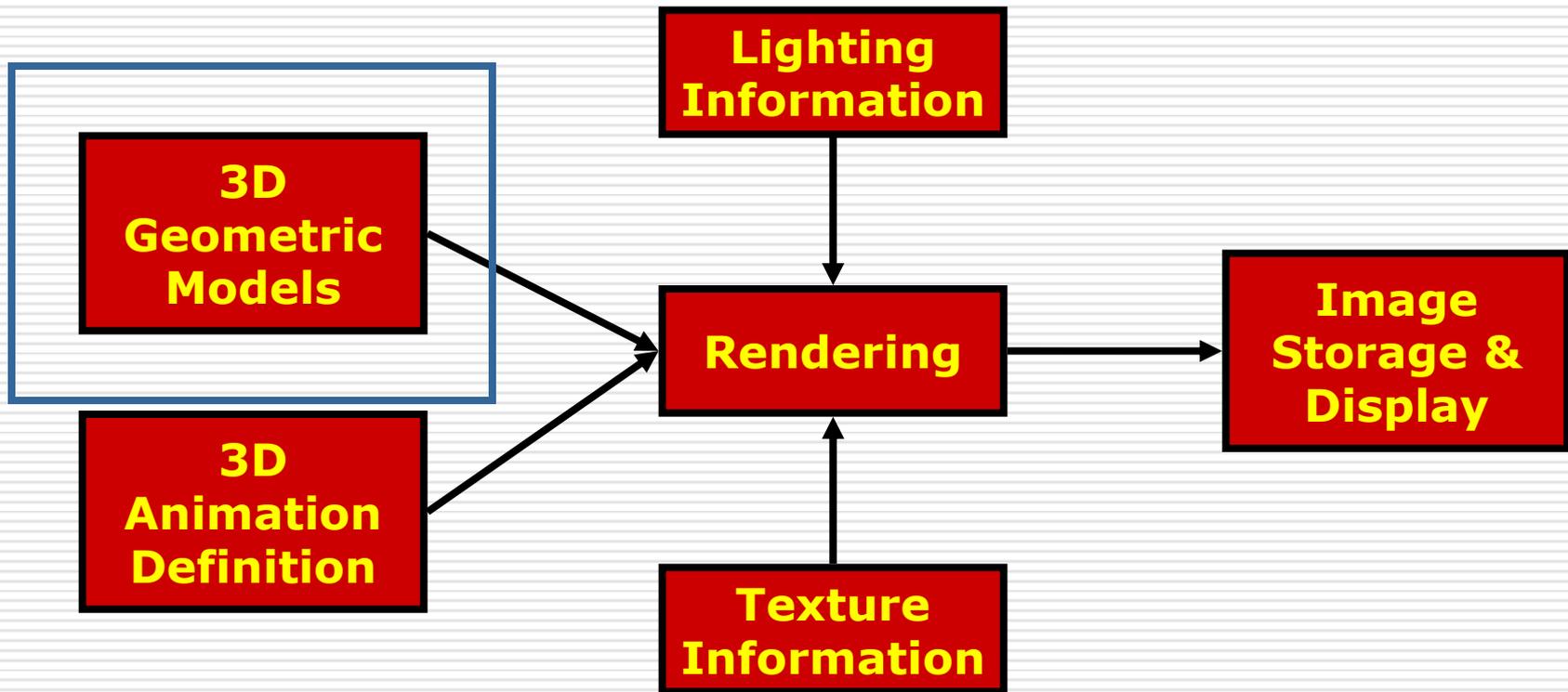
<http://www.graphics.cornell.edu/online/box/>

The Digital Michelangelo Project

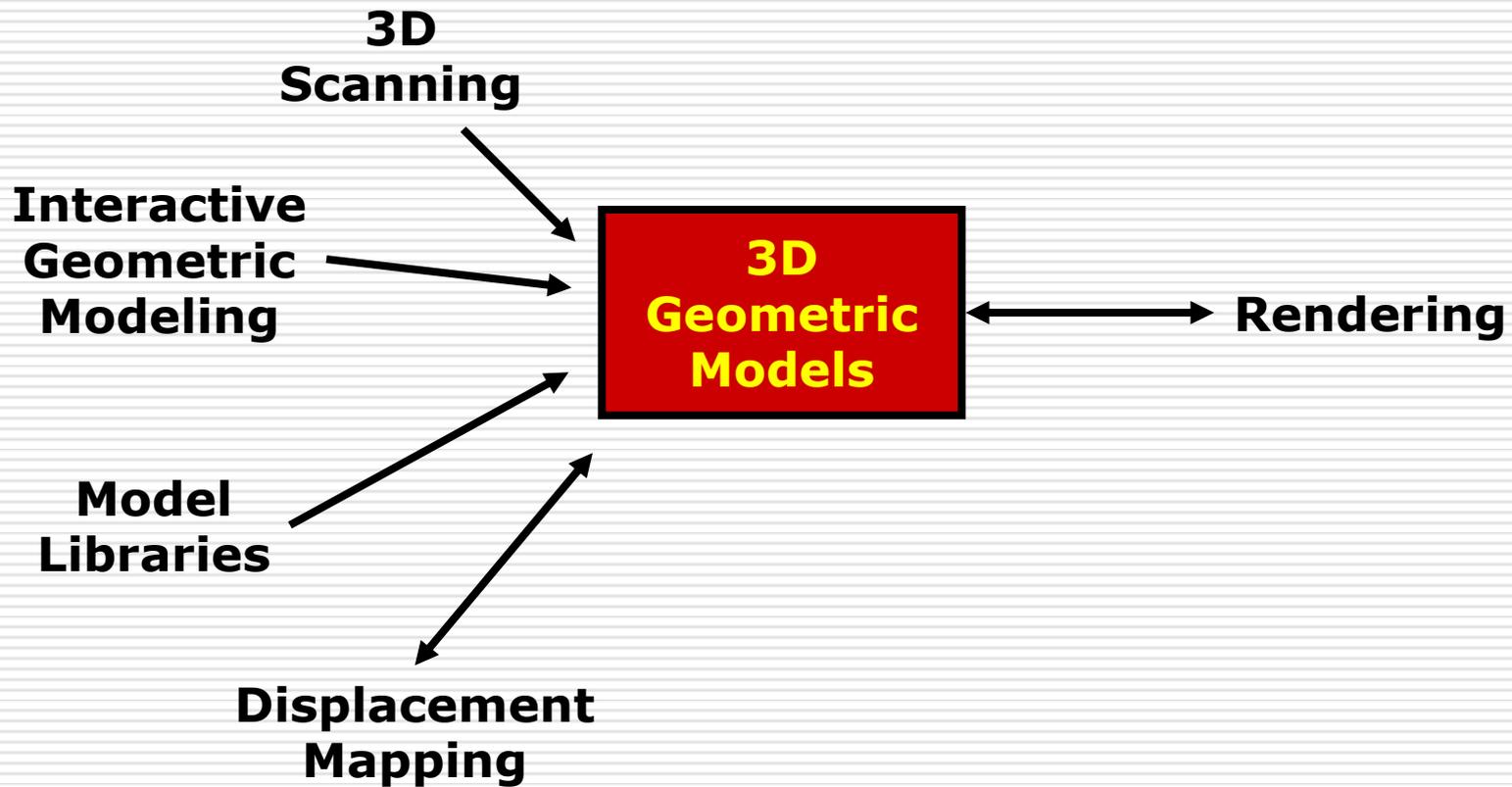


<http://graphics.stanford.edu/projects/mich/>

The Graphics Process



The Graphics Process: Geometric Modeling



3D Object Representations

□ Raw Data

- Point cloud
- Range image
- Polygon soup

□ Surfaces

- Mesh
- Subdivision
- Parametric
- Implicit

□ Solids

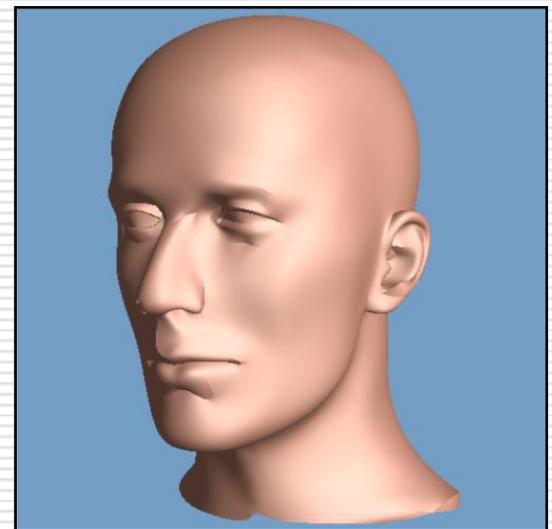
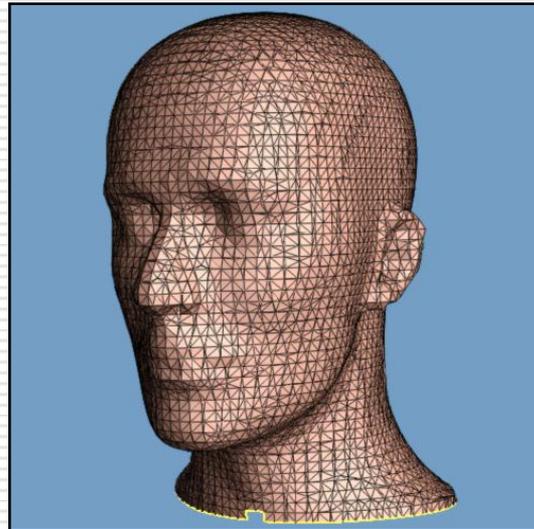
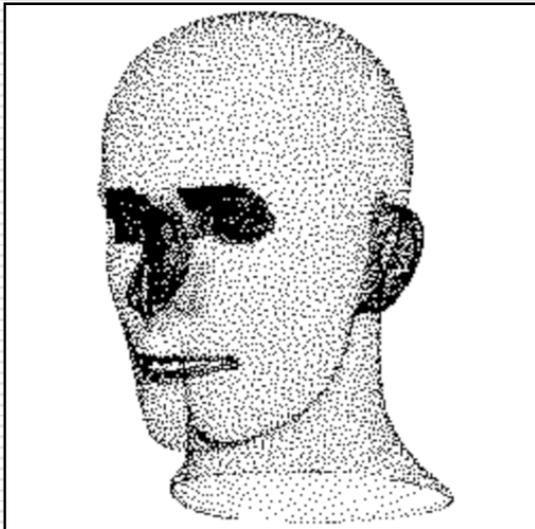
- Voxels
- BSP tree

□ High-level structures

- CSG
 - Constrained blocks
 - Skeleton
 - Sweep
-

Point Cloud

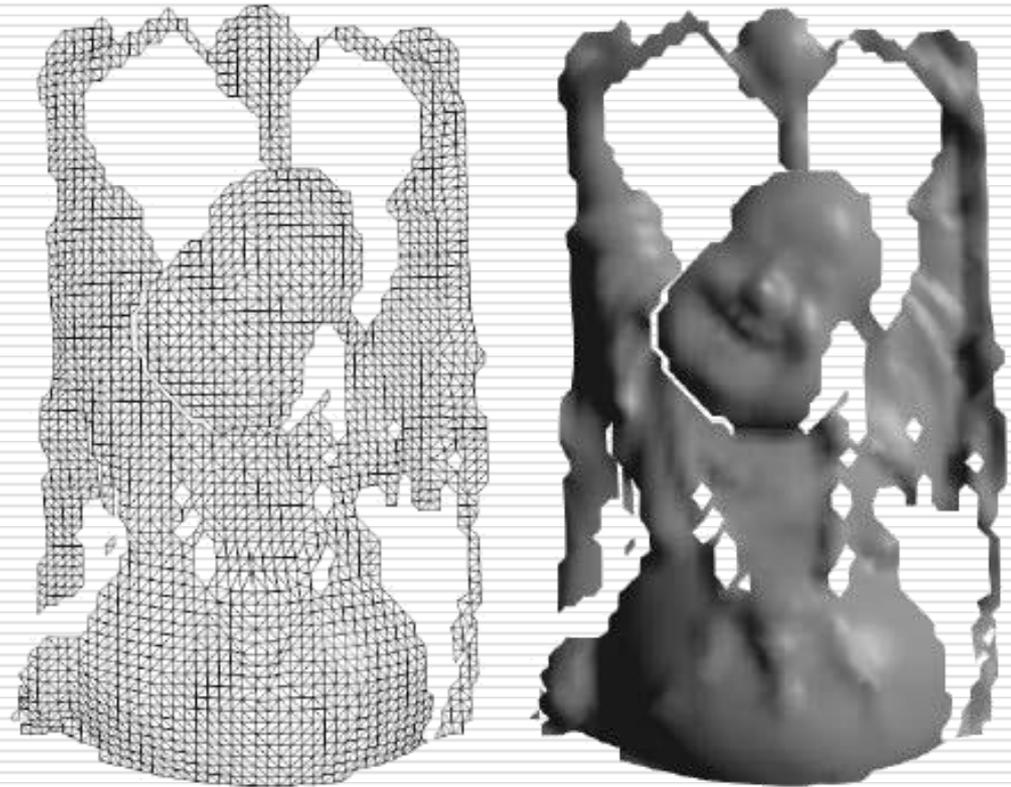
- unstructured set of 3D point samples
 - acquired from range finder, computer vision, etc.



Hugues Hoppe, Tony DeRose, Tom Duchamp, John McDonald, and Werner Stuetzle. Surface reconstruction from unorganized points. *ACM Computer Graphics (SIGGRAPH 1992 Conference Proceedings)*, Vol.26, No.2, p.71 - p.78, 1992.

Range Image

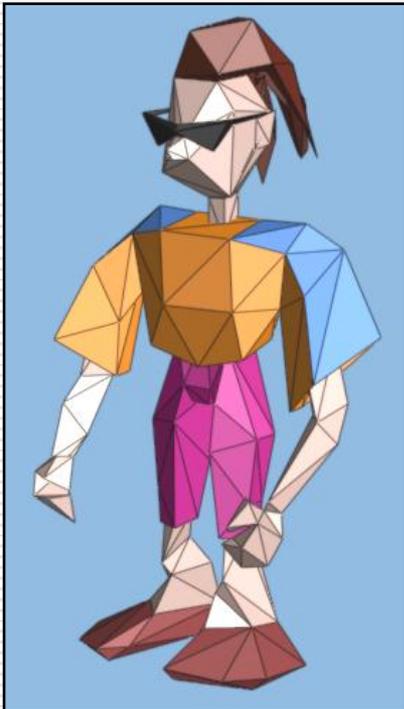
- set of 3D points mapping to pixels of depth image
- acquired from range scanner



Brian Curless and Marc Levoy. Surface reconstruction from unorganized points. *ACM SIGGRAPH 1996 Conference Proceedings*, p.303 - p.312, 1996.

Polygon Soup

- unstructured set of polygons
 - created with interactive modeling systems



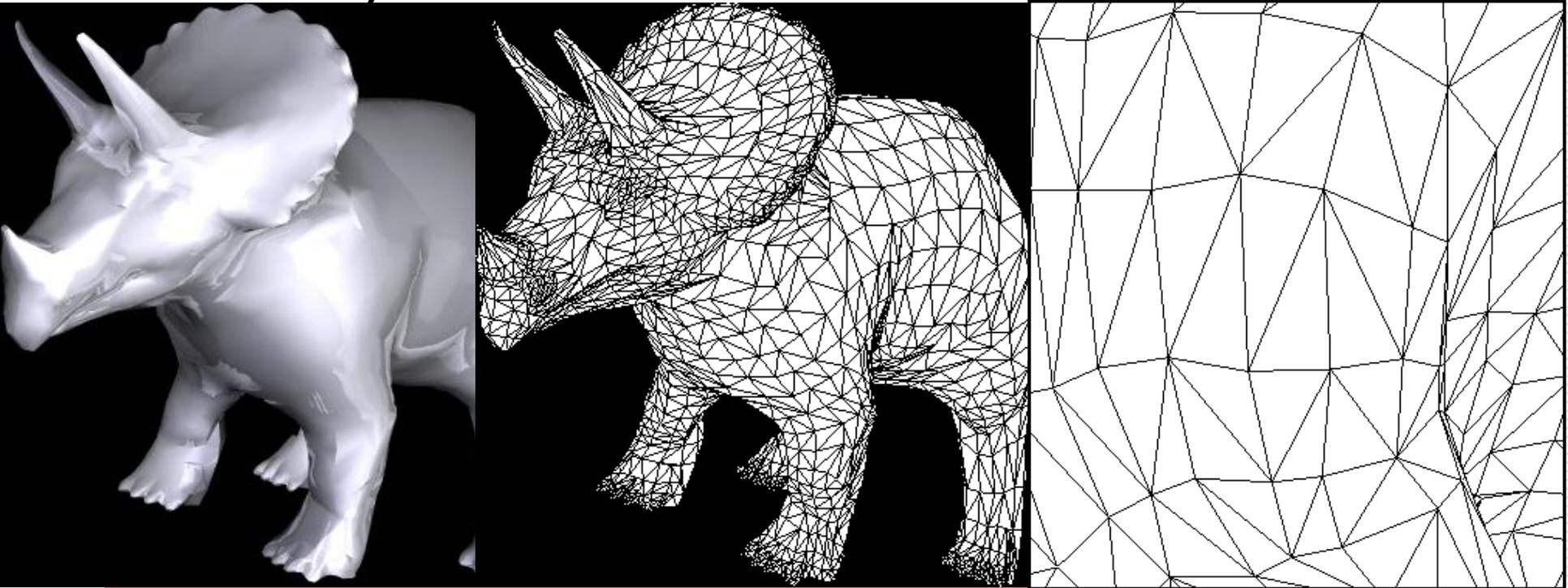
[Hoppe 99']



[Shen *et al.* 04']

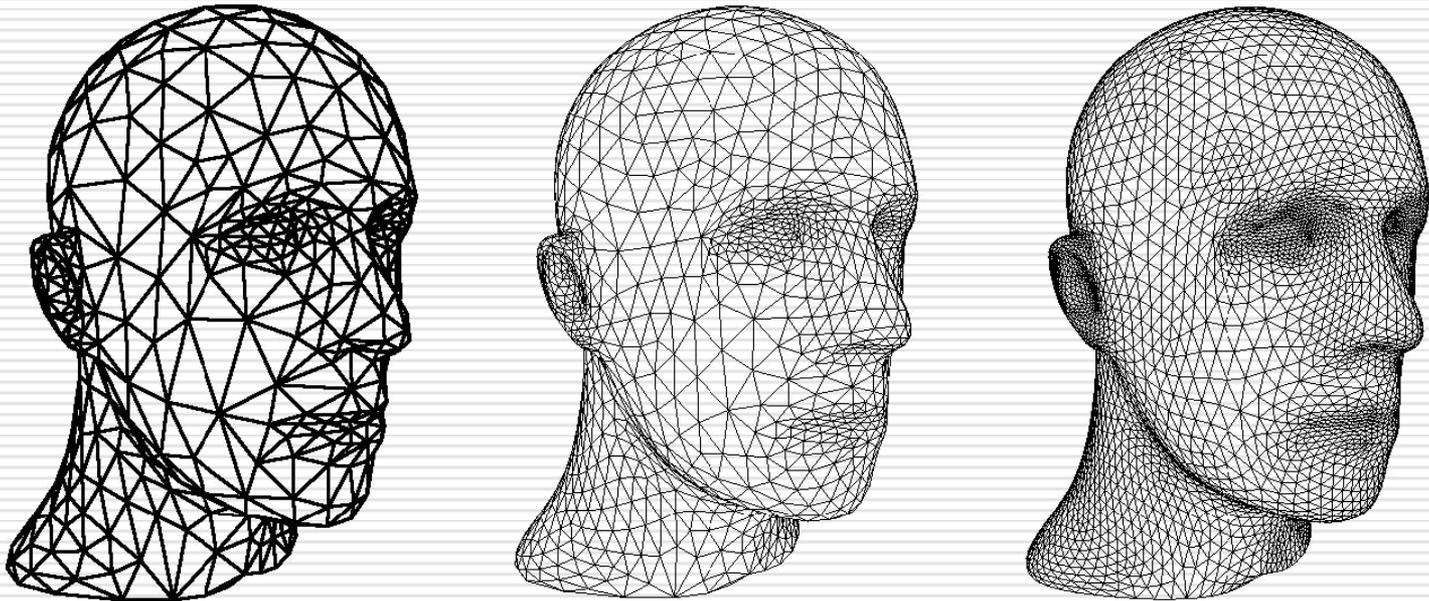
Mesh

- connected set of polygons (triangles)
 - may not be closed



Subdivision Surface

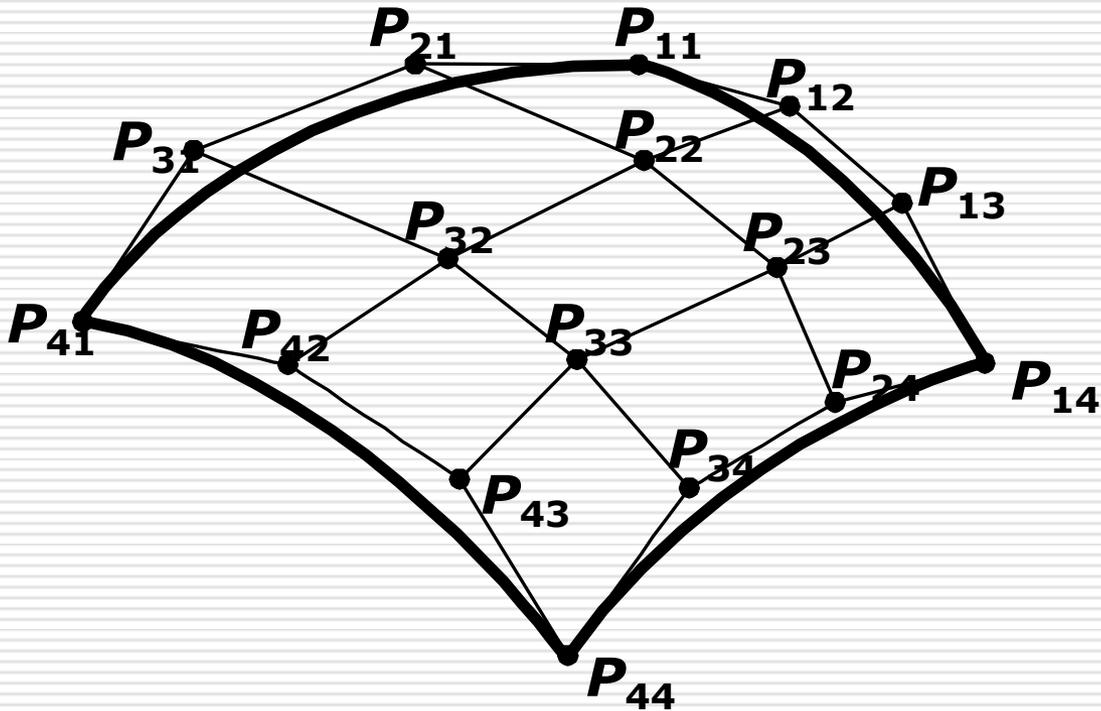
- coarse mesh & subdivision rule
 - define smooth surface as limit of sequence of refinements



Leif Kobbelt. Sqrt(3)-subdivision. *ACM SIGGRAPH 2000 Conference Proceedings*, p.103 - p.112, 2000.

Parametric Surface

- tensor product spline patches
 - careful constraints to maintain continuity



Implicit Surface

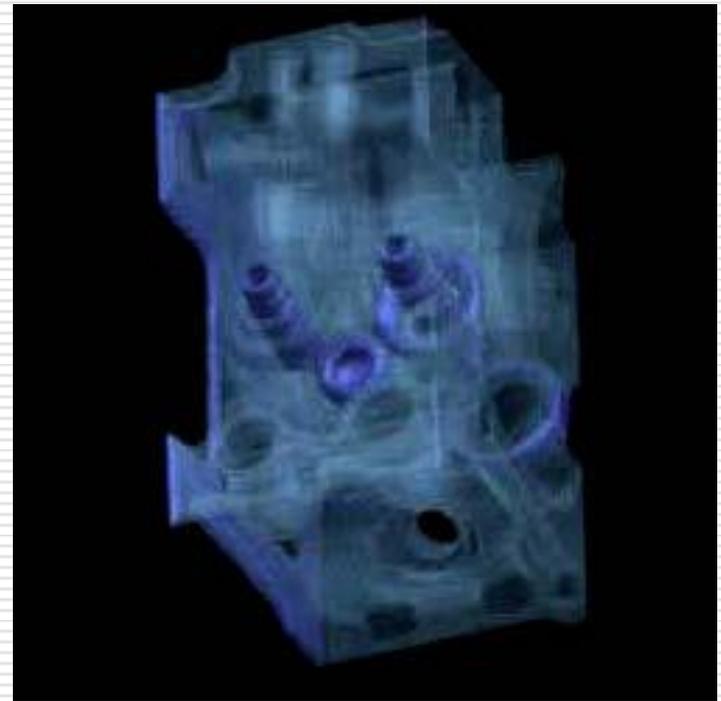
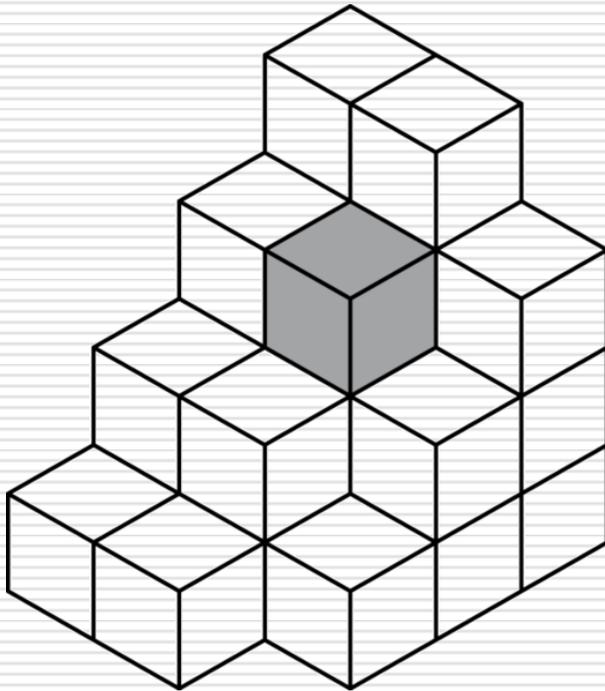
□ points satisfying: $F(x,y,z)=0$



Chen Shen, James F. O'Brien, and Jonathan R. Shewchuk. Interpolating and approximating implicit surfaces from polygon soup. *ACM Transactions on Graphics (SIGGRAPH 2004 Conference Proceedings)*, Vol.23, No.3, p.896 - p.904, 2004.

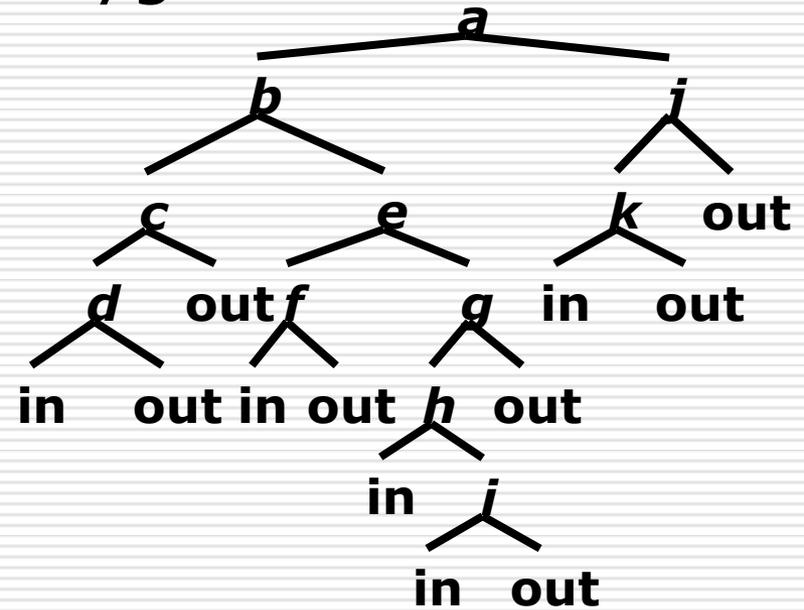
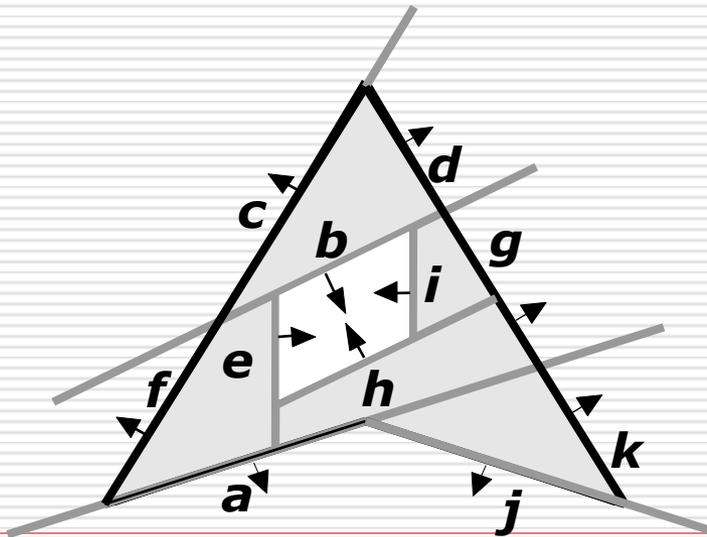
Voxels

- uniform grid of volumetric samples
 - acquired from CAT, MRI, etc.



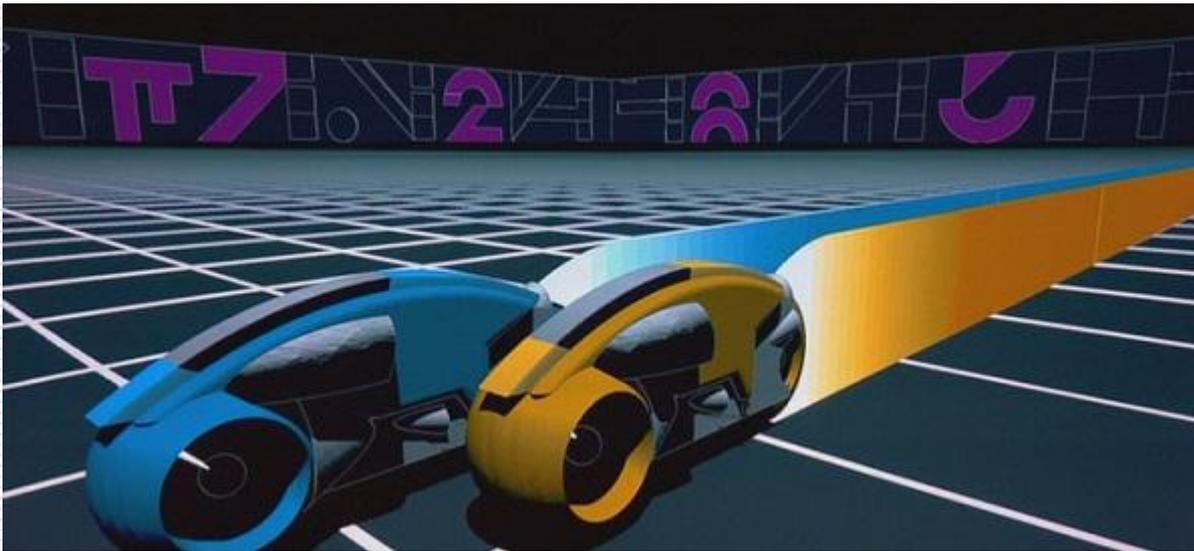
BSP Tree

- binary space partition with solid cells labeled
- constructed from polygonal representations

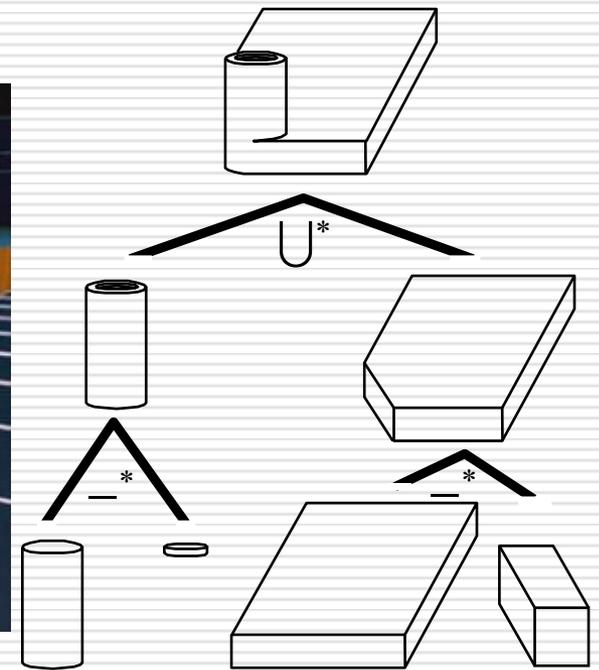


CSG = Constructive Solid Geometry

- hierarchy of Boolean set operations (union, difference, intersect) applied to simple shapes



Tron



Constrained Blocks

- set of simple shapes with geometric constraints



Paul E. Debevec, Camillo J. Taylor and Jitendra Malik. Modeling and rendering architecture from photographs: a hybrid geometry- and image-based approach. *ACM SIGGRAPH 1996 Conference Proceedings*, p.11 - p.20, 1996.

Skeleton

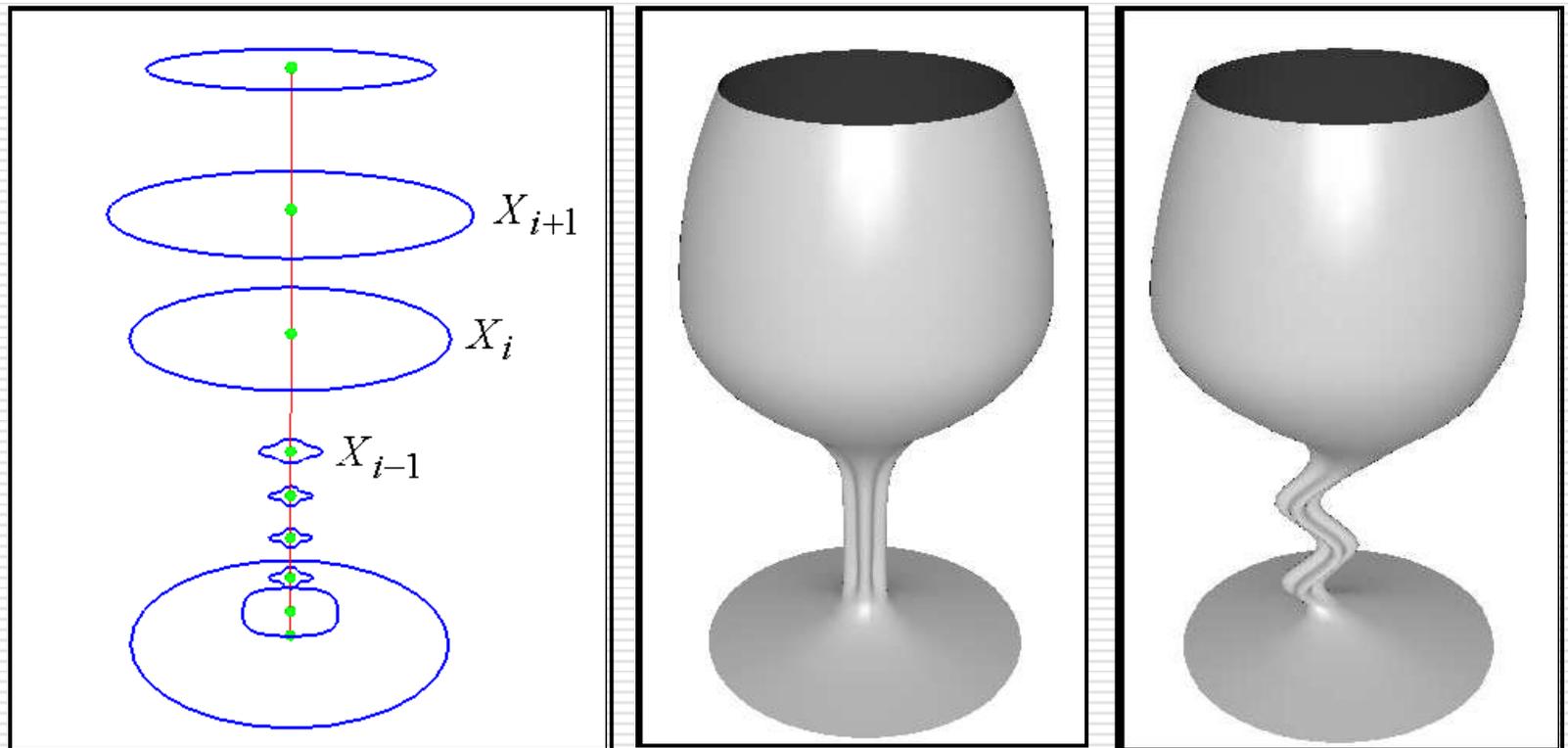
- graph of curves with radii



Sagi Katz and Ayellet Tal. Hierarchical mesh decomposition using fuzzy clustering and cuts . *ACM Transactions on Graphics (SIGGRAPH 2003 Conference Proceedings)*, Vol.22, No.3, p.954 - p.961, 2003.

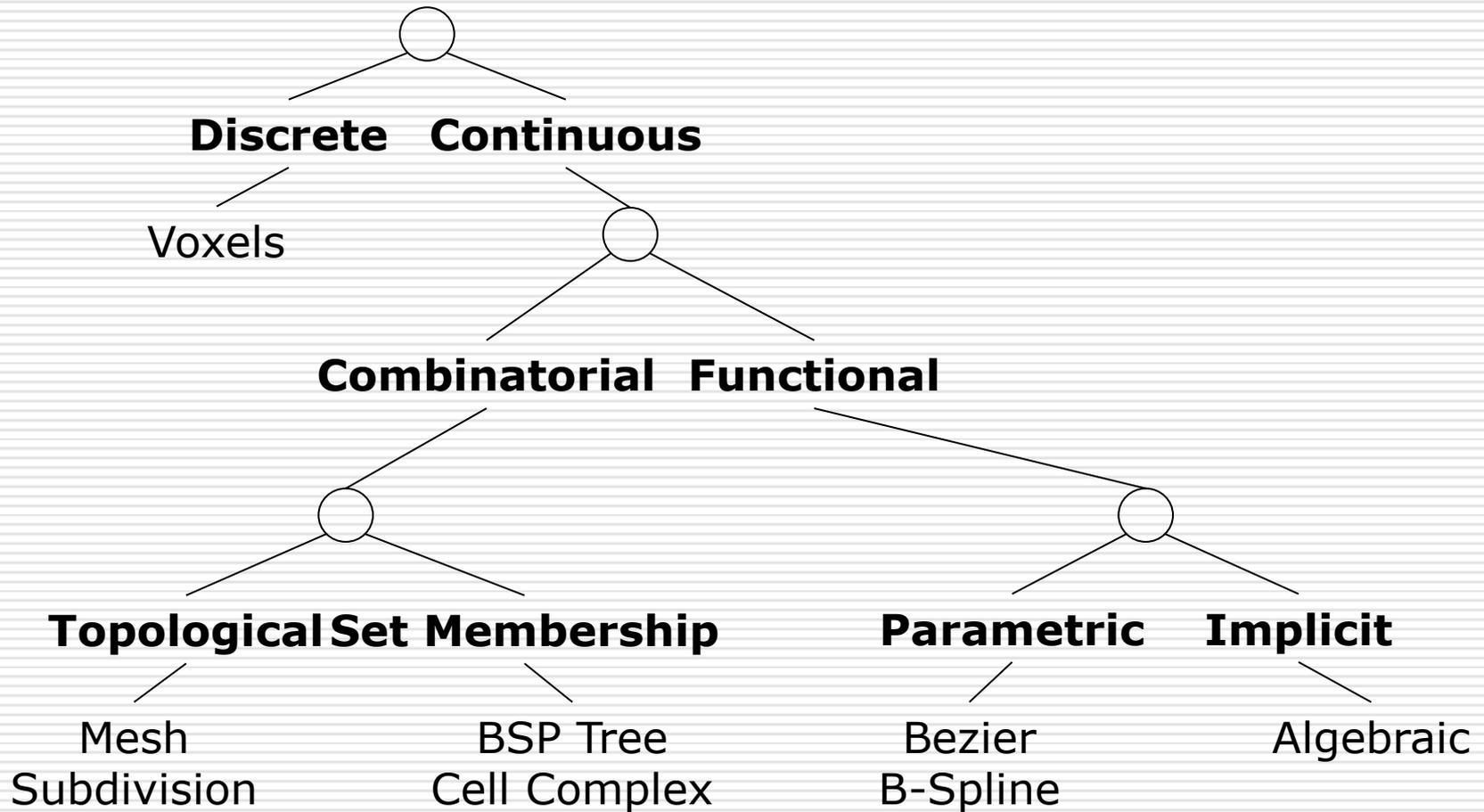
Sweep

- surface swept by curve along trajectory

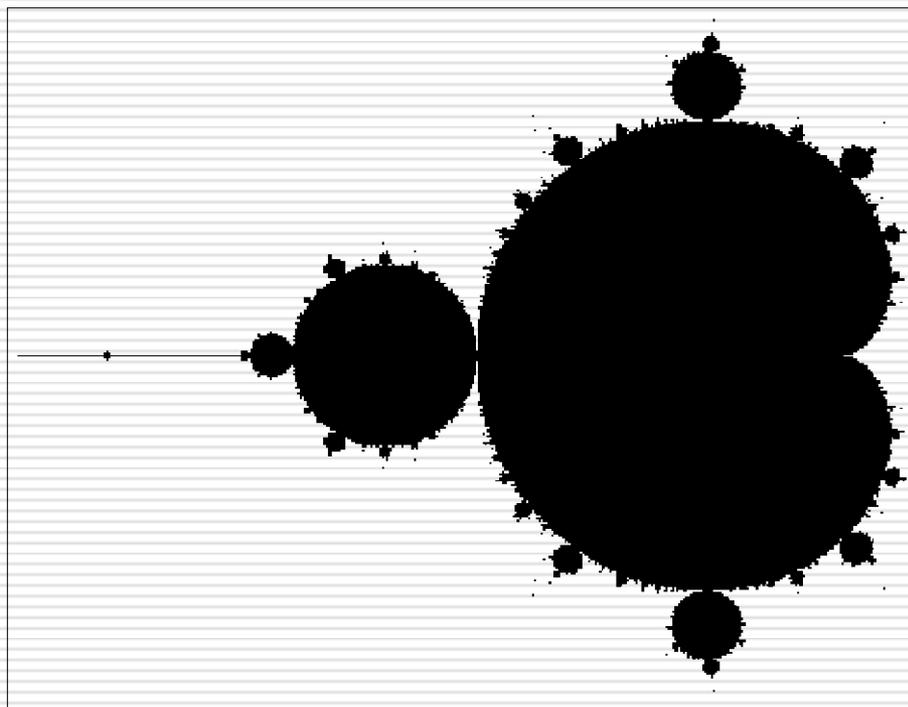
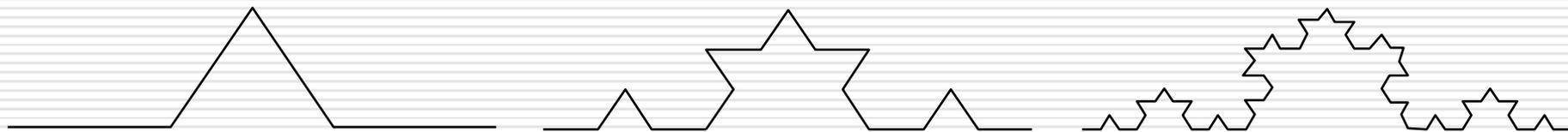


Seung-Hyun Yoon and Myung-Soo Kim. Sweep-based freeform deformations. *Computer Graphics Forum (Eurographics 2006 Conference Proceedings)* Vol 25 No 3 p 487 - p 496 2006

Taxonomy of 3D Representations



Fractal Models

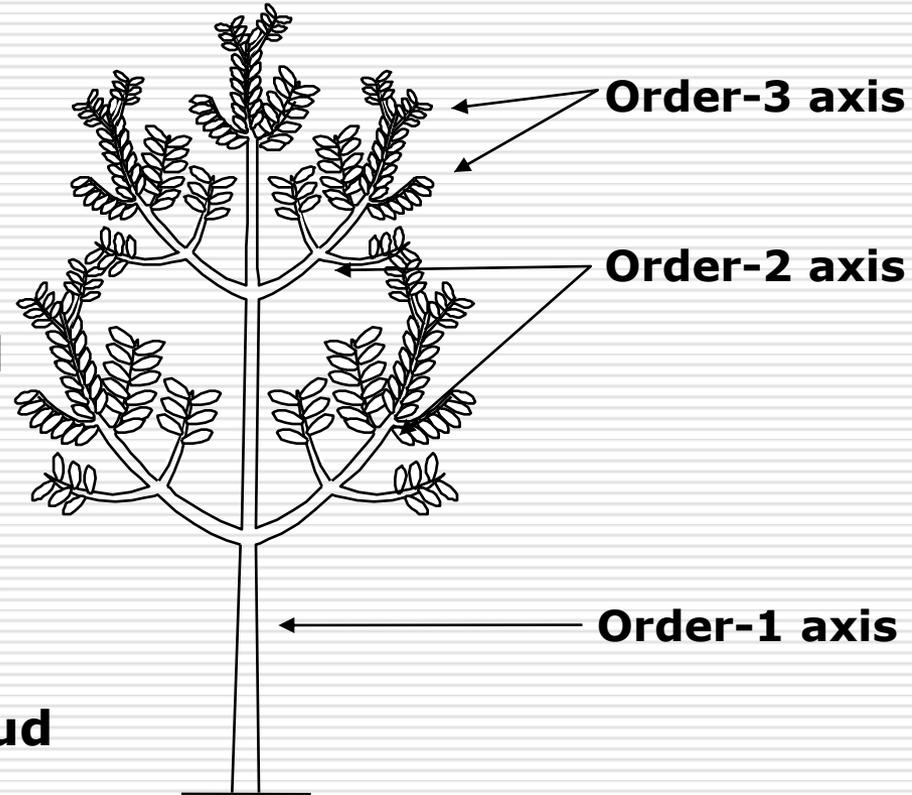
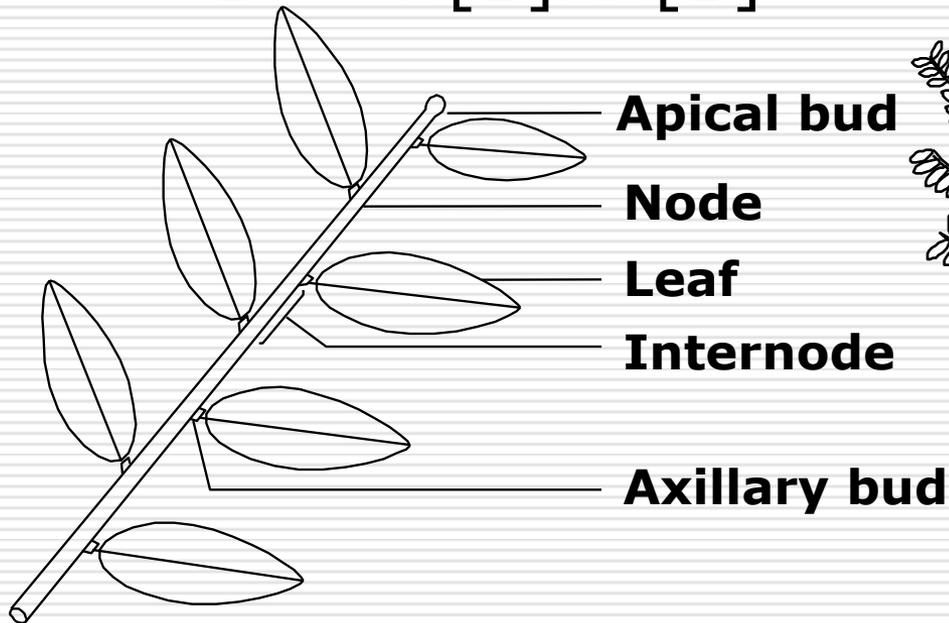


Grammar-Based Models

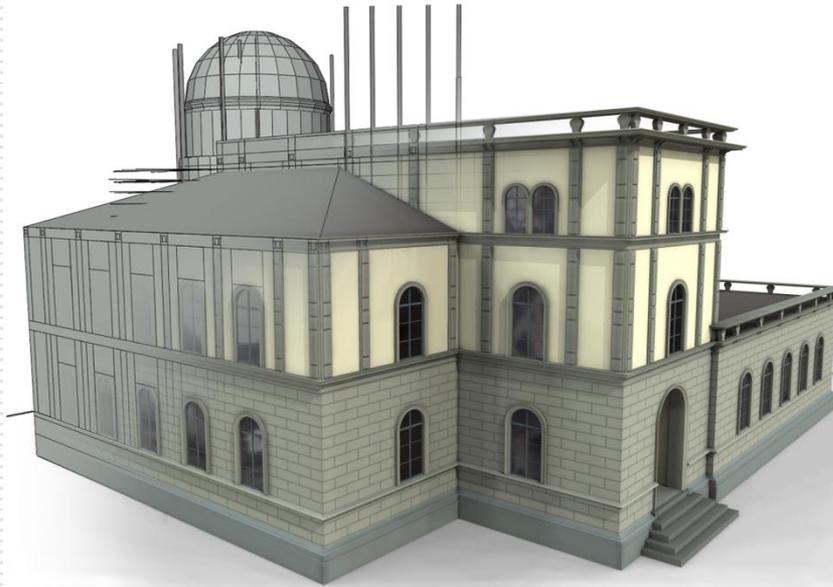
□ L-grammars

■ $A \rightarrow AA$

■ $B \rightarrow A[B]AA[B]$



Grammar-Based Models



Pascal Müller, Peter Wonka, Simon Haegler, Andreas Ulmer, and Luc Van Gool.
Procedural modeling of buildings . *ACM Transactions on Graphics (SIGGRAPH 2006 Conference Proceedings)*, Vol.25, No.3, p.614 - p.623, 2006.