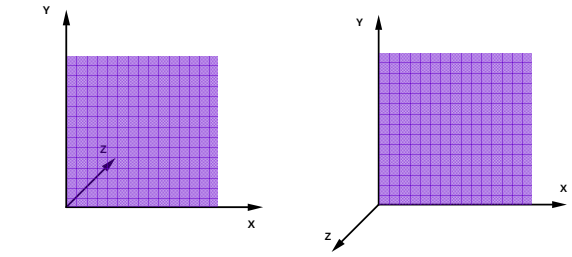
2. DEFINING OBJECTS: 3D REPRESENTATIONS

Coordinate systems
Surface representations
- Polygon tables

Volumetric representations - overview
- Constructive Solid Geometry
- Oct-trees

3-Dimensional coordinate systems

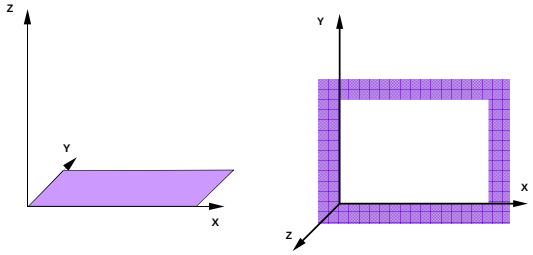


Cartesian left handed
Z axis goes "into" the page

Cartesian right handed
Z axis goes "out" of the page

In this course we use **right-handed** coordinate system

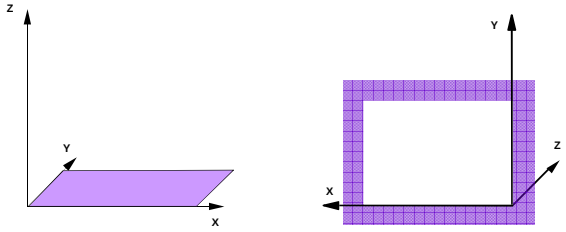
Right-handed coordinate system layouts



Z-up
Typically used in design

Y-up
Typically used in display / animation

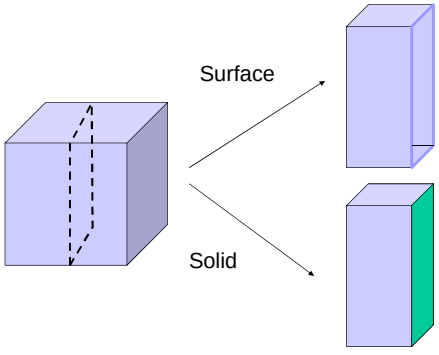
Right-handed coordinate system layouts



Z-up
Typically used in design

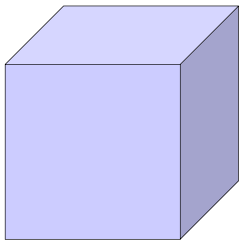
Y-up
Typically used in display / animation

Two classes of 3D representations

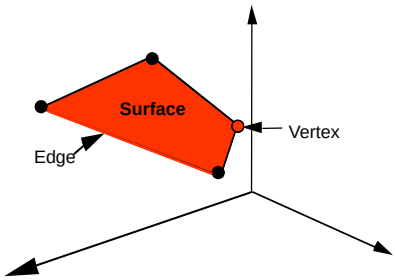


Surface representations

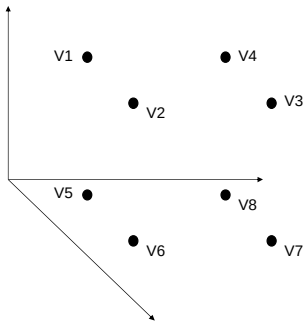
- Polygon surfaces



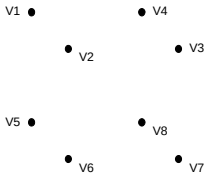
Surface representation

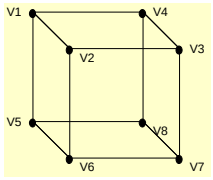


Vertices

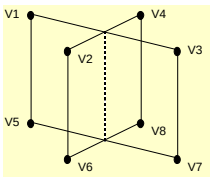


Wire-frame

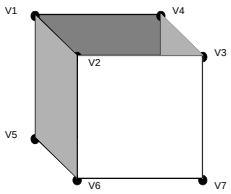


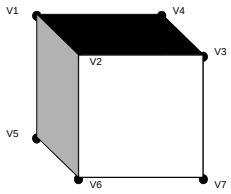


How many surfaces?



Surface





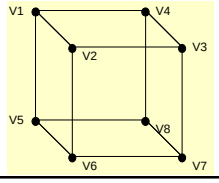
Surface (Boundary) representation

VERTEX TABLE

V1: x1 y1 z1
V2: x2 y2 z2
V3: x3 y3 z3
V4: x4 y4 z4
V5: x5 y5 z5
V6: x6 y6 z6
V7: x7 y7 z7
V8: x8 y8 z8

SURFACE TABLE

S1: V1 V2 V3 V4
S2: V5 V8 V7 V6
S3: V1 V5 V6 V2
S4: V2 V6 V7 V3
S5: V3 V7 V8 V4
S6: V1 V4 V8 V5



From vertices to surface patches

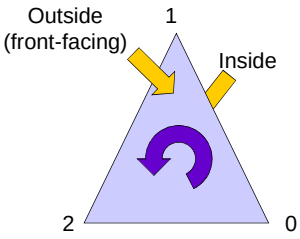
When constructing a surface patch,

does it matter

in what order we traverse the vertices?

YES

"In-s and Out-s" of triangles

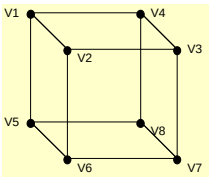


Right-hand rule

Exercise

VERTEX TABLE

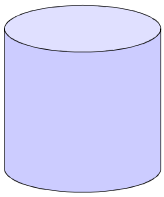
V1: x1 y1 z1
V2: x2 y2 z2
V3: x3 y3 z3
V4: x4 y4 z4
V5: x5 y5 z5
V6: x6 y6 z6
V7: x7 y7 z7
V8: x8 y8 z8

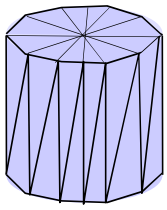


SURFACE TABLE

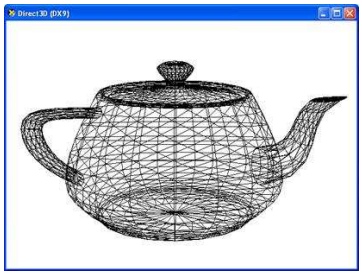
Surface representations

Surface patches





Surface representation: Utah teapot

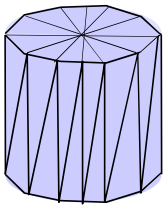


Source: http://www.codesampler.com/d3dbook/chapter_05/chapter_05.htm

Vertex table:
http://www.sjbaker.org/wiki/index.php?title=The_History_of_The_Teapot#The_Teapot_DataSet

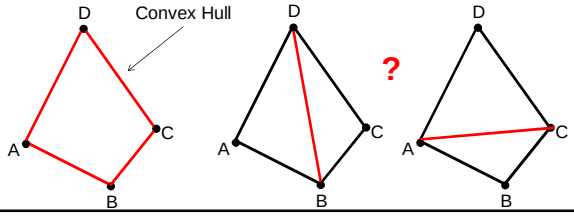
Source: http://www.graphics.cornell.edu/~westin/gallery/teapot.jpg

How to generate surface patches? Delaunay triangulation

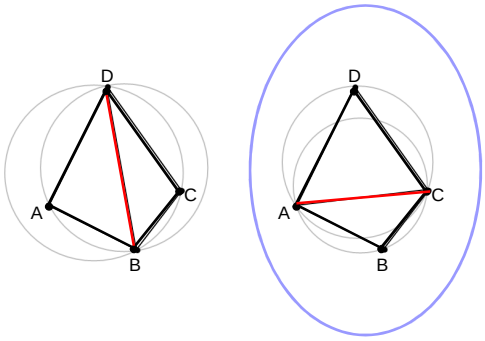


Delaunay triangulation

- Given a set P of points in a plane, create a triangular mesh DT(P) such that no point in P is inside the circumcircle of any triangle in DT(P).
- Delaunay triangulations maximize the minimum angle of all the angles of the triangles in the triangulation.



Delaunay triangulation



Consistency checking

- Every vertex is listed as an endpoint of at least two edges (lines)
- Every surface (polygon) is closed
- Each surface has at least one shared edge

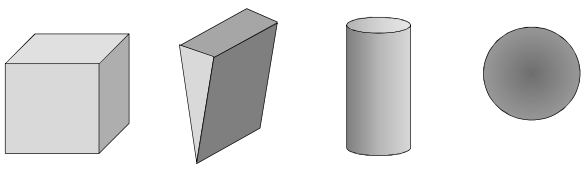
Representations for solids - overview

- Constructive Solid Geometry (CSG)
- Octrees

Volumetric Modules

Constructive Solid Geometry

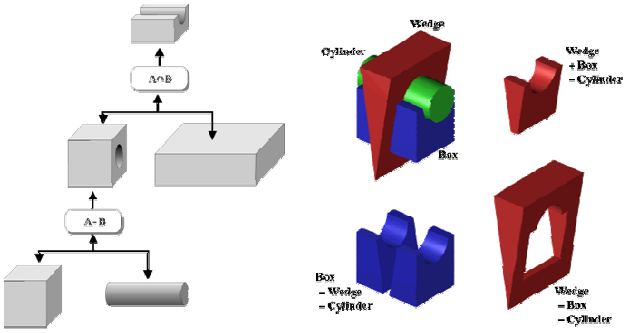
Primitives



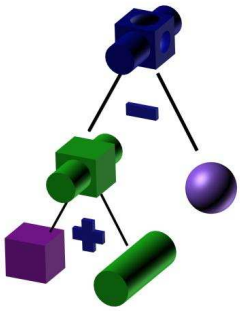
Box Wedge Cylinder Sphere

Volumetric Modules

Constructive Solid Geometry

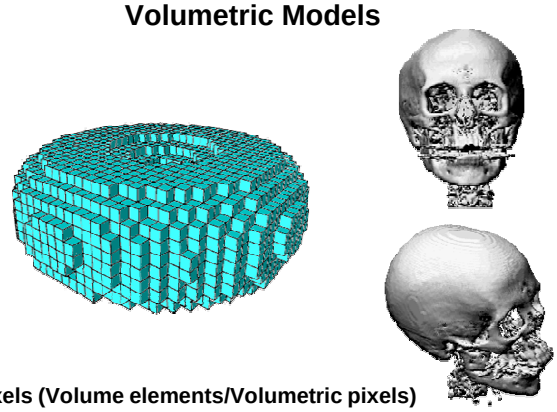


Constructive solid geometry



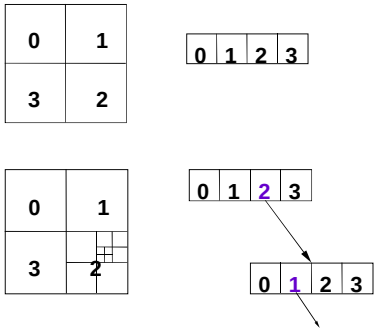
Source: http://groups.csail.mit.edu/graphics/classes/6.837/F98/talecture/

Volumetric Models

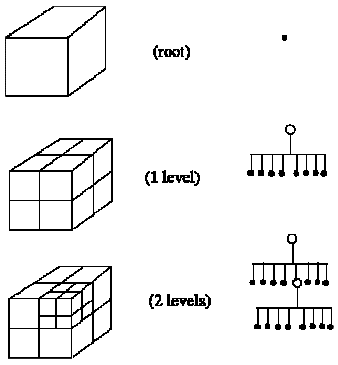


Voxels (Volume elements/Volumetric pixels)

Quadtrees



Octrees



Further reading

Surface modelling

- http://www.geometry.caltech.edu/pubs.html
- http://groups.csail.mit.edu/graphics/classes/6.837/F98/talecture
- http://escience.anu.edu.au/lecture/cg/surfaceModeling/index.en.html

Mesh triangulation (including Delaunay)

- http://www.cs.berkeley.edu/~jrs/mesh/
- http://www.visionbib.com/bibliography/describe436.html

Key concepts for surface representation in Java

- PointArray
- LineArray
- TriangleArray
- QuadArray
- LineStripArray
- TriangleStripArray
- TriangleFanArray

- See http://java.sun.com/developer/onlineTraining/java3d/j3d_tutorial_ch2.pdf (especially from p. 2-25, 2.5.2 Subclasses of GeometryArray)

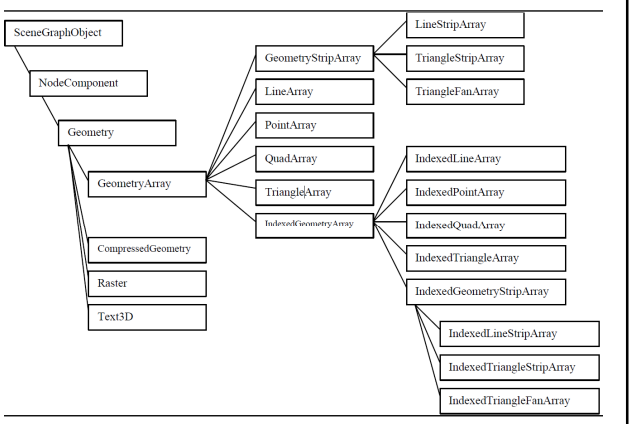
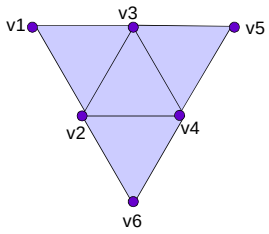


Figure 2-10 Geometry Class Hierarchy

Homework

1. Define Surface Representation (i.e. Vertex Table and Surface Table) for a pyramid with a triangular base. When specifying the Surface Table ensure that when the cut-out below is folded into the pyramid the triangle surfaces face correctly "in" and "out". Labels v1-v6 are vertex numbers, to be used in the construction of the Tables.



Homework

- Study matrix and vector operations. Tutorial is on-line at www.cs.bham.ac.uk/~exc/Teaching/Graphics/Mathematical_tools.pdf
- Do exercises in "Matrix and vector arithmetics" www.cs.bham.ac.uk/~exc/Teaching/Graphics/
- Solutions on-line next week

Matlab exercise

- Define a simple cube, display and manipulate. The outline of the Matlab code is in file www.cs.bham.ac.uk/~exc/Teaching/Graphics/ex1_simple_cube.m

Reminder about Matlab tutorials

- http://www.cyclismo.org/tutorial/matlab/
  - Work through the tutorial should take you 2-3 hours.
- http://www.cs.bham.ac.uk/~exc/Teaching/Graphics/Matlab_tutorial.pdf
- Matlab Help
  - Have a look at the "Programming" and "Graphics" sections

Next lecture

Sweep functions
Height maps
Elementary transformations