Lecture 10

Object representation:
Quadrics
Splines
Bézier patches

(Chapter 8.5-)

3D object representation

In order of importance:

- Polyhedra
- Bi-cubic parametric patches
- Procedural representation, fractals
- Constructive solid geometry
- Implicit representation by quadrics

plus...

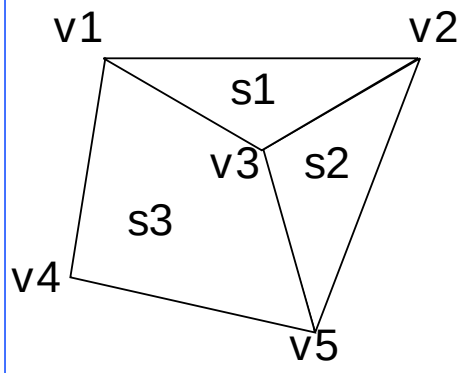
3D object representation

Advanced representations:

- Density volumes
- Point-based representations
- Level sets

Polyhedra representations

Dominant in real-time graphics
Less suited for off-line rendering



Vertex table

v1 = x1, y1, z1
v2 = x2, y2, z2
v3 = x3, y3, z3
v4 = x4, y4, z4
v5 = x5, y5, z5

Surface table

s1 = v1, v2, v3
s2 = v2, v5, v3
s3 = v1, v3, v5, v4

Making our own models

Many powerful commericial tools (Maya, 3D Studio Max etc)

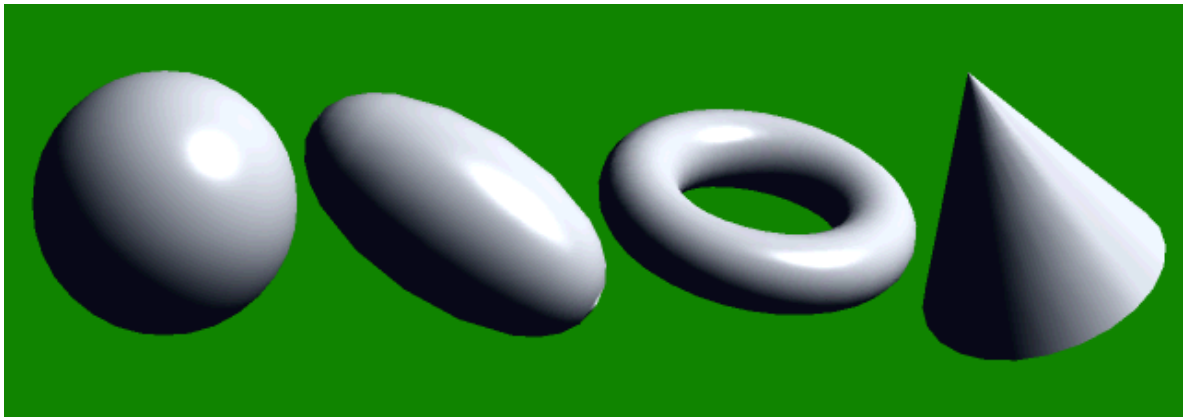
Free tools (nice for project work):

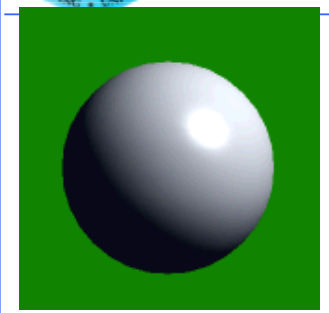
Blender
Wings3D

Implicit representations:
Quadric surfaces

Surfaces represented by second-degree polynomials

Sphere Ellipsoid Torus Cone

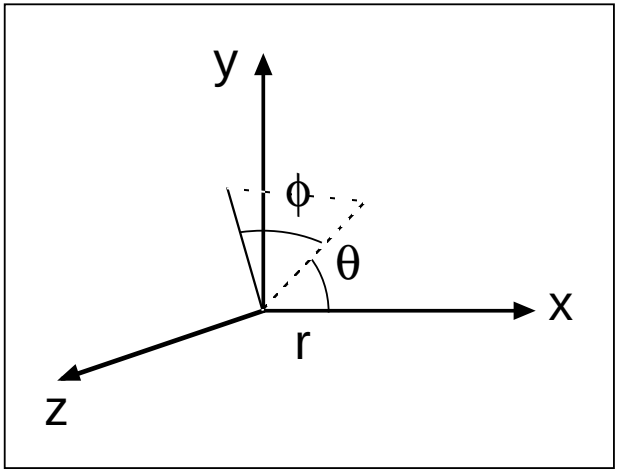




Sphere

Equation:

$$x^2 + y^2 + z^2 = r^2$$



Parametric:

$$x = r \cos \phi \cos \theta$$
$$y = r \cos \phi \sin \theta$$
$$z = r \sin \phi$$

$$-\pi/2 \leq \phi \leq \pi/2$$
$$-\pi \leq \theta \leq \pi$$

Ellipsoid

Equation:

$$x^2/r_x^2 + y^2/r_y^2 + z^2/r_z^2 = 1$$

Parametric:

$$x = r_x \cos\phi \cos\theta$$
$$y = r_y \cos\phi \sin\theta$$
$$z = r_z \sin\phi$$

$$-\pi/2 \leq \phi \leq \pi/2$$
$$-\pi \leq \theta \leq \pi$$

Torus

Rotate a circle around an axis

Equation:

$$(r - \mathrm{sqrt}(x^2/r_x^2 + y^2/r_y^2))^2 + z^2/r_z^2 = 1$$

Parametric:

$$x = r_x\,(r + \cos\phi)\cos\theta$$
$$y = r_y\,(r + \cos\phi)\sin\theta$$
$$z = r_z \sin\phi$$

$$-\pi \le \phi \le \pi$$
$$-\pi \le \theta \le \pi$$

Quadric surfaces

Limited possibilities. Slightly more freedom can be achieved with “superquadrics”

Many quadric surfaces are hard to rotate freely

Rendering packages replace them with meshes (polygons or curved surfaces)

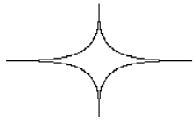
Are quadrics outdated?

Superquadrics:

Example: Superellipse

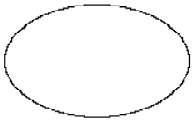
$$x = r_x \cos^s\theta$$
$$y = r_y \sin^s\theta$$
$$(x/r_x)^{2/s} + (y/r_y)^{2/s} = 1$$

s = 0.1



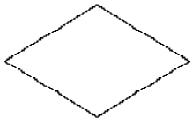
s = 5.0

s = 0.5

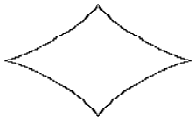


s = 1.0

s = 1.5



s = 2.0



s = 2.5

Quadric surfaces in OpenGL

Calls that approximate quadric surfaces by polygons

glutWireSphere/glutSolidSphere

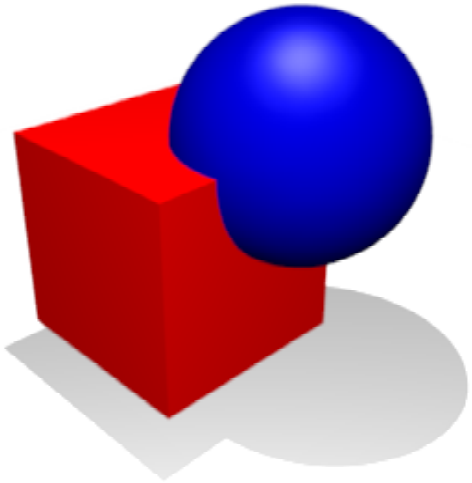
glutWireCone/glutSolidCone

glutWireTorus/glutSolidTorus

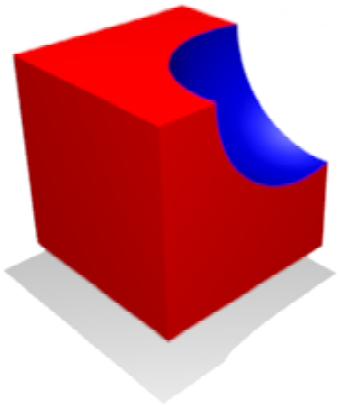
(Not for GL3+)

Constructive Solid Geometry

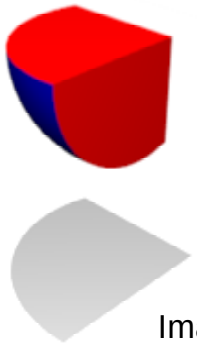
Define shapes by Boolean operations on other shapes



Union (a or b)



Difference (a and not b)



Intersection (a and b)

Images from Wikipedia

Constructive Solid Geometry

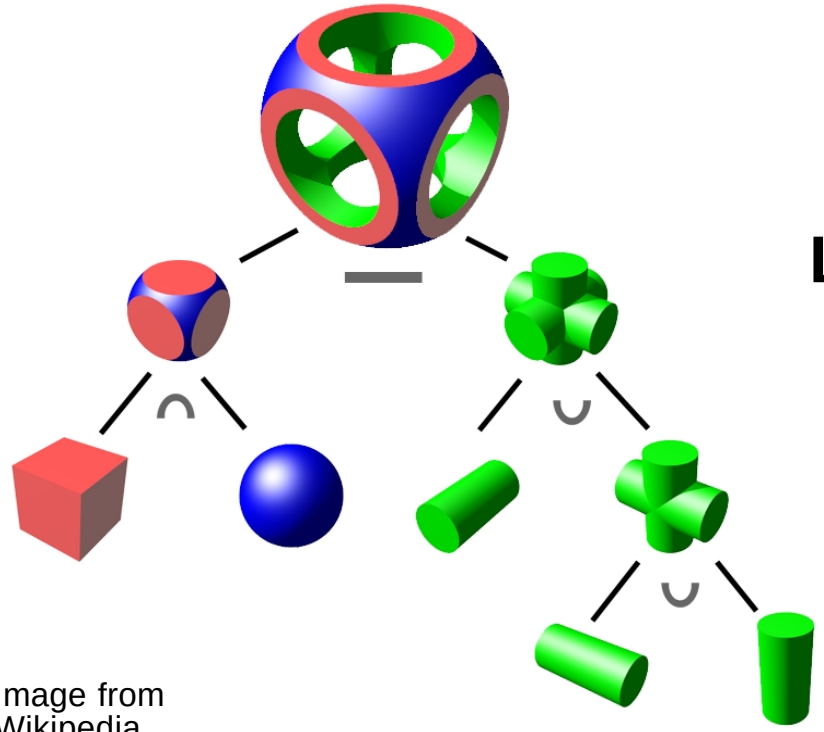


Image from Wikipedia

Good shapes in - somewhat useful.

Limited shapes in - limited results.