3D object representation

In order of importance:

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

plus...

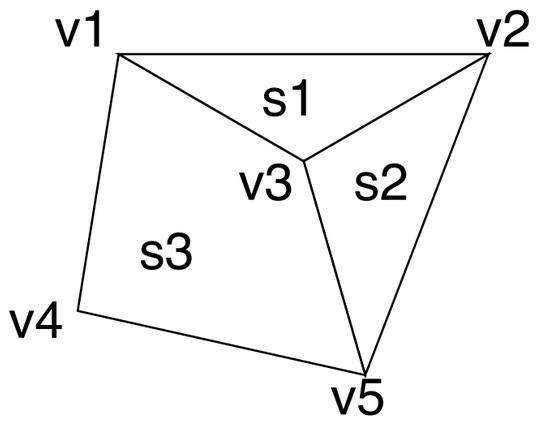
3D object representation

Advanced representations:

- Density volumes/voxel representations
- Point-based representations, including blobby objects
- 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)

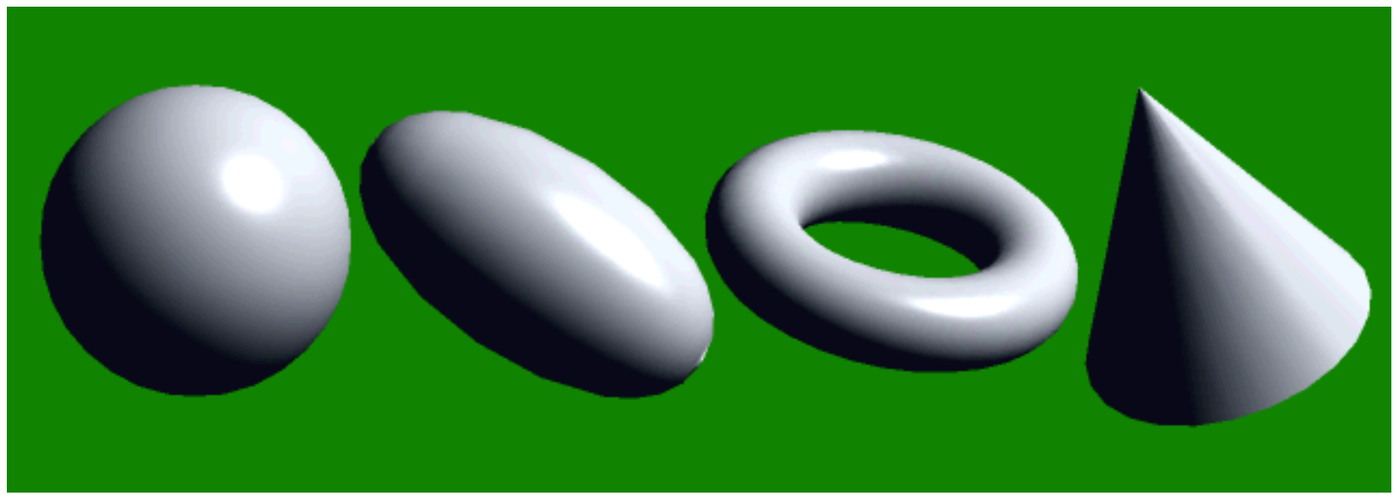
Free tools (nice for project work):

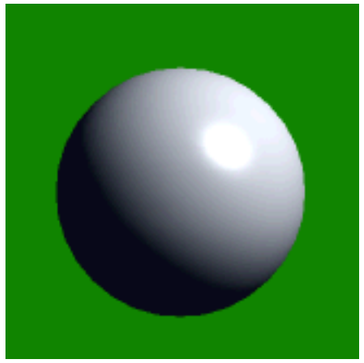
Blender
Wings3D

Implicit representations:
Quadric surfaces

Surfaces represented by second-degree polynomials

Sphere Ellipsoid Torus Cone





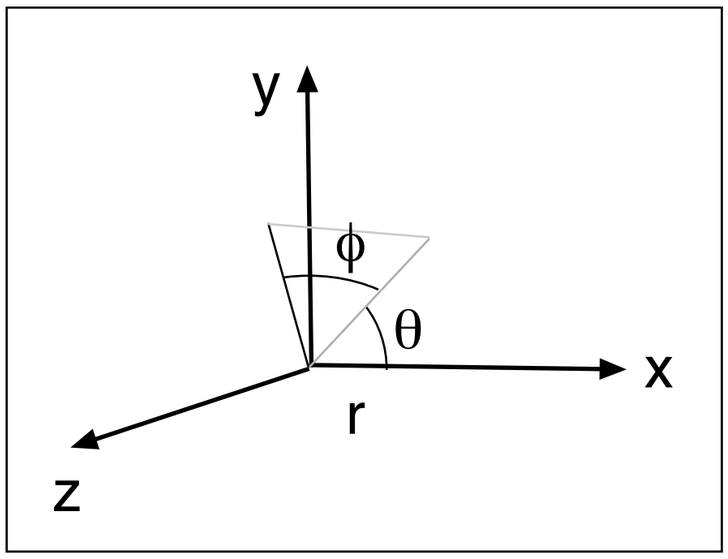
Sphere

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:

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

$$-\pi \leq \phi \leq \pi$$
$$-\pi \leq \theta \leq \pi$$

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)

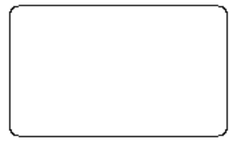
Are quadrics outdated?

Superquadrics:

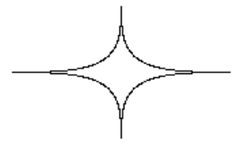
Example: Superellipse

$$x = r_x \cos^s\theta$$
$$y = r_y \sin^s\theta$$

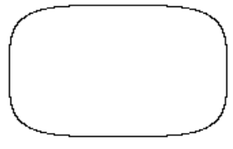
$$(x/r_x)^{2/s} + (y/r_y)^{2/s} = 1$$



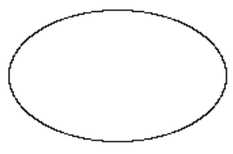
s = 0.1



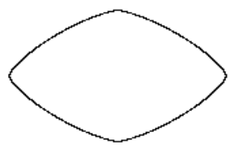
s = 5.0



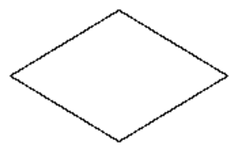
s = 0.5



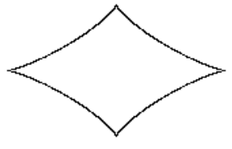
s = 1.0



s = 1.5



s = 2.0



s = 2.5

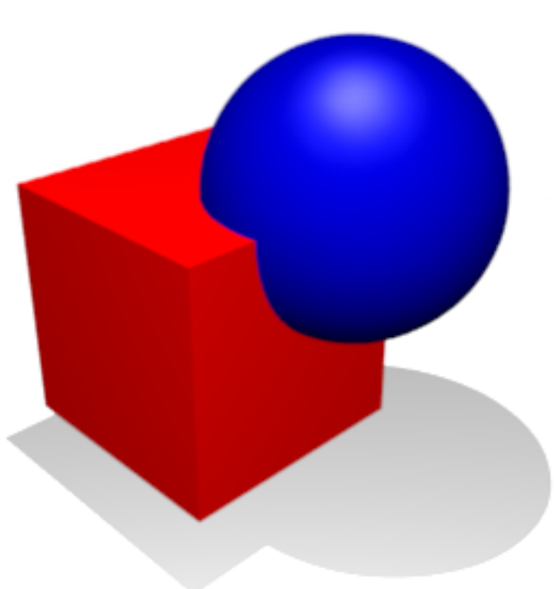
So where do we find quadrics today?

- **Raytracing (especially simpler ones)**
- **Bounding shapes for VSD**
- **Simplified collisions**

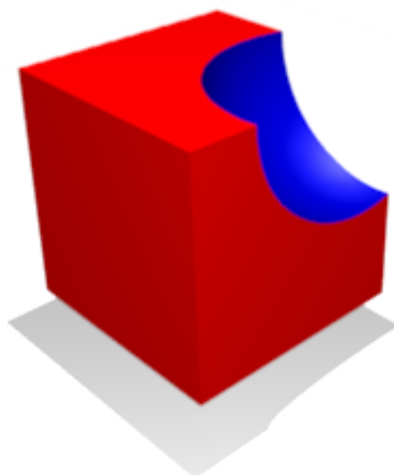
but rarely for real-time rendering

Constructive Solid Geometry

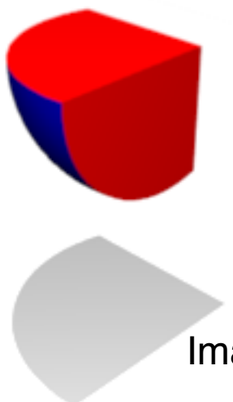
Define shapes by Boolean operations on other shapes



Union (a or b)



Difference (a and not b)



Intersection (a and b)

Images from Wikipedia

Constructive Solid Geometry

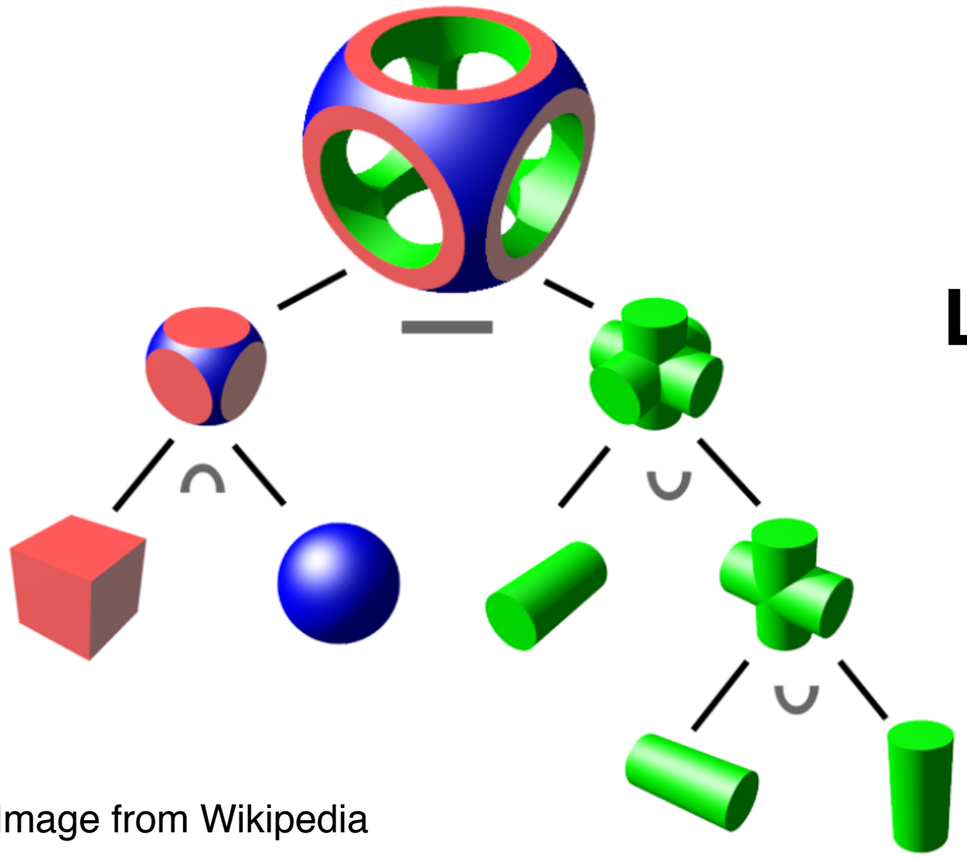


Image from Wikipedia

Good shapes in - somewhat useful.

Limited shapes in - limited results.