geometric modeling

- representations
  - conversions
- creation
- manipulation

representations

- how is geometry represented internal to some program
- one can often convert from one rep to another.
  - some operations are easier in some reps

equal soup

- a list of triangles
- each triangle has 3 vertices
- each vertex has 3 coordinates
- shared vertices may be replicated, or pointed to
- each tri-vert has other attributes
  - e.g. normal, texture coordinates
- can associate 2d textures as well as normal maps for rendering
- + easy to render, +easy to acquire

equal soup

- like triangle soup but can have more verts per poly
- + may be more natural in some settings (architecture)

equal (poly) meshes

- the base geometry is polygon soup
- lets assume that the geometry is a “surface”
- each edge has two adjacent faces.
- each vertex has a “one-ring” of vertices
- basic idea is to include various pointers in the data set so one can “walk” around the data
  - what are all the vertices “around” a given vertex
  - which poly is across an edge from a given poly
- this allows us to do all kinds of surface processing operations.
  - eg. smoothing, LOD.
- there are many different such data-structures (fig)
- the bunny will be represented with one such data structure

parametric surfaces

- recall that we could use splines to describe a curve \( x(t), y(t) \) with parameter \( t \).
• describe \( x(s,t), y(s,t), z(s,t) \) coordinates as a function of \( s,t \)
• usually using some piecewise bivariate polynomial form (fig)
• bezier, ubs, nubs, nurbs
• +concise representation of smooth patch
  – +can be adaptively triangulated for rendering as needed
• +allows for somewhat intuitive direct control
• -hard to stitch together multiple patches smoothly to create closed object

**subdivision surfaces**

• parametric surfaces can be evaluated using repeated subdivision of input grid
• generalize to non-grid mesh (code demo)
• +concise representation of smooth shape
  – +can be adaptively triangulated for rendering as needed
• +allows for somewhat intuitive direct control
• +no need for explicit stitching
• -a bit harder to reason about, or texture map

**implicit surfaces**

• given some smooth scalar function \( f(x,y,z) \)
• define surface as points with \( f = 0 \)
  – the sign for non-zeros tells you inside vs out (p:surf2:5, vid)

**how to define \( f \)**

• some algebraic function
  – useful for spheres and other famous canonical shapes
• meta-balls
• define some decreasing function of distance from seed point or segment
• add up functions for all seeds (demo and p:surf2:9)
• +concise representation of smooth shape
• +allows for somewhat intuitive direct control
• +no need for explicit stitching
• +easy to do topology changes
• +easy to find where a ray intersects with surface
• -somewhat hard to turn into polygons (more later)
• +well defined notion of inside and outside (e.g. csg video).
• -hard to do 2d texture map

**volume representation**

• can have a 3d grid with “density” values at each grid point
• may come from mri scan or from numerical simulation (p:solid:1,3)
• can render slices
• can “interpolate” the values over each cube
• this essentially gives us an scalar function over space
• can render as a 3d semi-transparent fog (vid)
• can interpret use iso-surface as implicit surface(psolid:4)

transformations
• from soup to mesh involves algorithmic stitching
• from parametric to mesh involves (adaptive) direct evaluation
• from mesh to parametric surface involves “optimizing” the fit (ppt)
• from implicit to polygons involves “contouring” (marching cubes vid)
• from closed mesh to volume involves “3d rasterization”

creation
• geometric scanners (lasers, cameras, satellites) (w:cyb)
• typically outputs cloud of points (with colors)
• need to turn this into a mesh (ppt)

simulation
• run a fluid simulator and output a volume rep

procedural
• use some code to generate a shape (ppt)
• fractals (vid)

authoring tool
• software that lets you perform various “tasks” to build up a model.
• often builds stuff up from curves, and basic shapes, plus deformation
• (vid)
• mesh based editing (vids)