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

triangle 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-ver 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

polygon soup

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

triangle (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.
  - e.g. 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)