Johns Hopkins
Engineering for Professionals

605.767 Applied Computer Graphics

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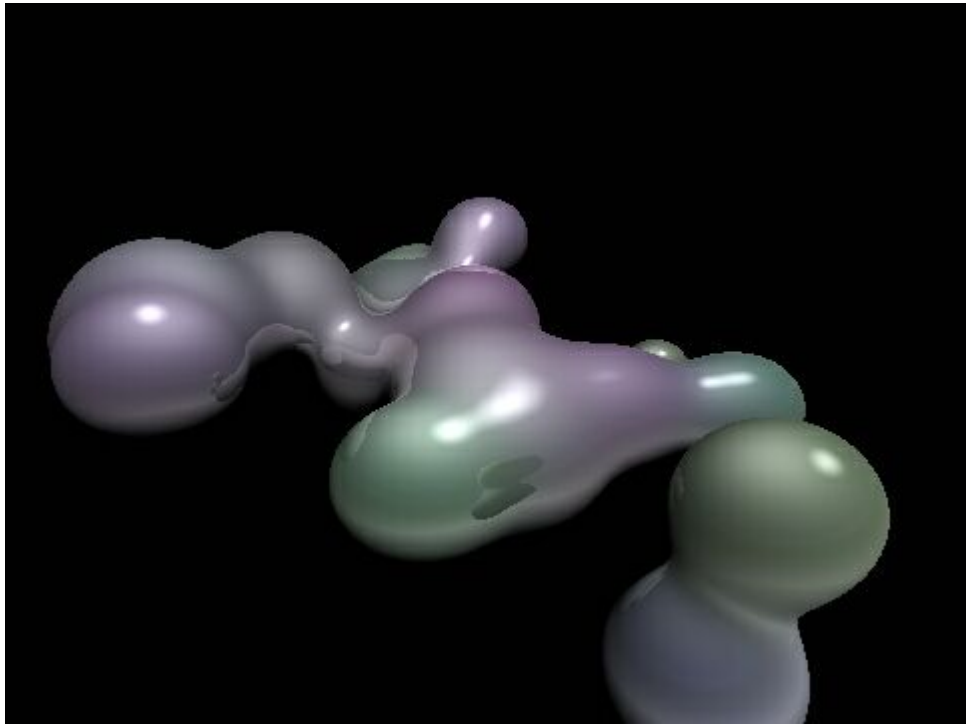
Module 7B
Implicit Surfaces

Implicit Surfaces / Blobby Objects / Metaballs

http://fuzzyphoton.tripod.com/rtref/rtref_b.htm#blobbyobject



http://www.geisswerks.com/ryan/BLOBS/blobs.html

Implicit Surfaces

- Implicit surface
  - f(x,y,z)=f(p)=0
    - A point p is on the implicit surface if f(p)=0
    - Sphere example: $x^2 + y^2 + z^2 - r^2 = 0$
  - Sometimes useful to form **isosurfaces** of an implicit function
    - f(x,y,z) = c
    - Sampled for a 3-dimensional space
- Blending of implicit surfaces produces a technique known as blobby modeling, soft objects, or metaballs
  - Many objects change shape during certain motions or when in proximity to other objects
    - Molecular structures, water droplets, human muscles
      - Molecular shape is spherical in isolation but changes shape when near other molecules
  - Characteristics cannot be adequately described by simple spherical or elliptical shapes
- Modeling packages often provide support for blobby objects

Blobby Objects

- Models have been developed to represent blobby objects as distribution functions over a region of space
  - One method models objects as combinations of Gaussian density functions
  - Parameter b can be altered to produce produce dents or bumps
- Other blobby object methods use density functions that fall off to 0 in a finite interval, rather than exponentially
  - 'Metaball' model describes composite objects as combinations of quadratic density functions of the form
    - $f(r) = b\,(1 - 3r^2 / d^2)$ $\quad 0 < r < d/3$
    - $f(r) = 3/2b\,(1 - r/d)^2$ $\quad d/3 < r <= d$
    - $f(r) = 0$ $\quad r > d$
  - 'Soft object' model uses the function
    - $f(r) = 1 - 22r^2/9d^2 + 17r^4/9d^4 - 4r^6/9d^6$ $\quad 0 < r <= d$
    - $f(r) = 0$ $\quad r > d$

Rendering Blobby Objects

- Can convert an isosurface into a triangle mesh using **Marching Cubes** algorithm
  - 3-dimensional grid over entire surface
  - Sample implicit function at each grid point
    - Each grid point is either inside or outside the implicit function
  - Each cube has 8 points
    - 256 combinations
    - Each combination yields 0-4 triangles inside the cube to represent the implicit surface
- http://en.wikipedia.org/wiki/Marching_cubes
  - Algorithm was patented (expired in 2005)