Implicit Surface Rendering

1. Ray tracing
   - Ray Marching
   - Sphere Tracing
2. Polygonization

Implicit Surface Polygonization

- Tiling surface with polygons/triangles
- Spatial partitioning in cells
- Cell polygonization

Discrete vs Continuous Data

**Discrete data:**
- Data only in vertices of cells
- E.g., obtained from medical data
- Interpolation to obtain continuous data
- Estimated cell/surface intersection

**Continuous data**
- Given by an implicit function
- Function evaluation can be very expensive

Partitioning - 1

- Accuracy or cell size
- Fixed vs adaptive resolution

Partitioning - 2

- Subdivision: octree/quad tree
- Enumeration: list of all cells

Cell Polygonization - 1

- Each vertex of cell is inside or outside volume
- An edge with an inside and outside vertex intersects the surface
Vertex $v_0$ is inside, value $f_0$
Vertex $v_1$ is outside, value $f_1$
Iso-value = $f$

Estimated intersection point:

$\left( (1-\alpha)v_0 + \alpha v_1 \right)$

With $\alpha = \frac{f-f_0}{f_1-f_0}$

Cell Polygonization - 3

Computation vs interpolation

accurate

interpolated

Cell Polygonization - 4

Normal vector computation
- use normalized gradient: $\nabla f / ||\nabla f||$

Gradient can be computed or approximated:

$\nabla f = \left( \frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z} \right)$

$\nabla f \approx \left( \frac{f(x+\Delta,y,z)-f(x-\Delta,y,z)}{2\Delta}, \frac{f(x,y+\Delta,z)-f(x,y-\Delta,z)}{2\Delta}, \frac{f(x,y,z+\Delta)-f(x,y,z-\Delta)}{2\Delta} \right)$

Ambiguity
Disambiguate carefully and consistently, otherwise holes in the surface result.

Decomposition in tetrahedra eliminates ambiguities.
Shrink Wrapping

Polygon-set = large polygonized sphere

\begin{algorithm}
while (offset \neq 0) {
  move vertices to offset surface;
  divide some of the edges;
  move new vertices to offset surface
  along gradient;
  reduce offset;
}
\end{algorithm}

Iterations

Triangle subdivision