Volume Rendering

Isosurface
Isosurface

- A closed surface separates outside and inside
- For volume data, define "isovalue"
  - All voxels with values bigger than isovalue are inside and others outside
  - Then, an surface is defined by this isovalue, the "isosurface"

- cross-section of a smooth sphere
  - iso-value = 50 will render a large sphere
  - iso-value = 200 will render a small sphere
Isosurfaces of volumes

iso-value = 30
iso-value = 80
iso-value = 200
Volume rendering of isosurface

- Ray casting method
- Stop the ray once we get the interpolation results of a sampling point
- Define the color with gradient shading method
- Normal = normalize (gradient)
• How to find good iso-value?
  – Make histogram of the voxel densities
Step Size

- Step size for ray casting has to be smaller than 1.0 so that we will not miss any voxel
- Smaller step size will give more accuracy
- But will compromise the computation speed
Iso-surface Rendering

• Transform volumetric data sets to surface model
  – Use polygon rendering methods
  – Use polygon manipulation methods
    • Deformation
    • Morphing
    • ...

• An reverse procedure of “voxelization”

• Voxelization: Polygons → volumes
Marching Cubes Algorithm

- Approximate isosurface with a triangle mesh generated by comparing isovalue and voxel densities
- Look at each cell of the volume one by one and generate triangles inside the cell by the configuration of voxel values
Marching Cubes

- Imagine all voxels above the isovalue are 1 and others are 0
- Find triangular surface includes all 1s and excludes all 0s
- Each of the 8 corners of one cell can be 0 or 1, totally we have $2^8 = 256$ cases
- Can be reduced to 15 cases use symmetry
Marching Cubes Algorithm

- Exact positions of the triangle vertices are determined by linear interpolation of the isovalue.

\[ iso = v_1 \cdot (1-u) + v_2 \cdot u \quad \rightarrow \quad u = \frac{v_1 - iso}{v_1 - v_2} \]
Marching Cubes Algorithm

- Generally can be fast computed by a Lookup table
- Have some ambiguous cases
- Refers to:
- Some source codes available online