Visualization
December, 2007

CS559 Class Notes
(not for projection)

Visualization

- Helping someone see something
  - Data Visualization (information)
  - Data Visualization (scientific)
  - Architectural, Engineering, Artistic, …
- Visualization referring to a field
  - Scientific data
  - Information
  - Seperation somewhat historical (spatial abstraction)

Scientific Data Visualization

- A whole big field – could be a course
- Hit some high points (parallel with book)
- Could be anything
  - Drawing graphs like in high school physics
  - Medical illustrations
- Generally field is more focussed
  - How to display large / regular data sets
  - Some basic/general concepts

Scalar Field Data

- A common form of data
- Doesn't matter what field is
- Range, Domain
  - $R = f(D)$ D in R^n
  - Could be vector valued
- Samples across the domain
  - Regular sampling (like an image)
  - Irregular sampling

"Easy" Version 2D

- $R = f(x,y)$ (an image)
- How to display?
  - An intensity (why? Why not?)
  - Psuedo coloring R->(r,g,b)
    - Makes things stand out, emphasis
    - Can lie with colorings
  - Contour lines – isocontours
  - Height field (add shading to emphasize)

A Common Hard Case: 3D

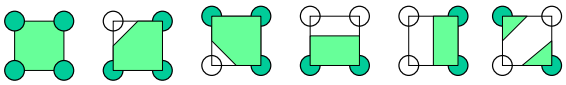
- Scalar field in 3D $v = f(x,y,z)$
- Common to have regular samples
- Important cases:
  - Medical images (CT, MRI)
- Often just slice (since 2D is easier to visualize)
  - Still preferred in medicine

3D Scalar Fields

- Method 1: Make isosurfaces
  - Gives a “solid” surfaces, use normal surface methods to show it
- Isosurface extraction method:
  - Marching cubes
  - Explain as 2D – marching squares
    - Data a points on grid
    - Need to decide where edges go
    - 2^4 cases of how the region might be filled

Marching squares

- Each square can be in 1 of 16 configurations
- Can Adjust edge intersect point based on where “level crossing” is



Marching cubes

- 256 (2^8) cases
- Gives a slightly blocky surface
  - Can be smoothed
- Really only lets you pick one “isovalue”
  - Can change isovalue, get new surface
- Isosurface rendering
  - Useful for looking at specific objects within a field (a bone inside a CT scan)

Direct Volume Rendering

- Treat each square as a density
  - Lets some light through
  - Changes the color
- Trace path through the volume
- Maximum intensity projection
- Integral along the line (as if ray is going through transparent cells)
- Transfer function
  - (what each value does to ray)
  - Effects Opacity and Color
  - Can depend on normal (to get fake lighting)

Beyond scalar fields

- Vector Fields
  - Every point has a vector x,y,z = F(x,y,z)
  - Velocity fields
  - Force fields
  - Fluid visualizations
- Tensor fields
  - Matrix / coordinate system at every point
  - Get from various MRI technologies
    - Which way things can wiggle

Challenges of Sci-Vis

- Making sure you can see things
- Managing complexity
  - Computationally (big data sets)
  - Conceptually (limits of perception)