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
  – Separation 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)