Volume Visualization with Ray Casting

http://web.cs.wpi.edu/~matt/courses/cs563/lectures/ray-cast.htm
www.cs.technion.ac.il/~zdevi/volume/Volume.ppt

Volume Rendering

- render an image a volume
  - CT, X-ray, PET, MRI scans
  - Clouds
  - Compressible fluids
- volume represented by 3D cell grid

Volume Rendering

Typical sizes
128x128x128
256x256x256

Display approaches
Extract surfaces
Ray trace

Ray Casting

- Generate image directly from density data
- Cast ray through density volume
- Accumulate colors as ray passes through semi-transparent cells
Density: \( D(t) = D(x(t), y(t), z(t)) \)

Accumulate illuminated densities

\[ I(t)D(t)P(C \cos \theta) \]

\( \tau \) converts density to attenuation

\[ B = \int_{t_1}^{t_2} \left( e^{-\int_{t_1}^{t} D(s) ds} \right) I(t)D(t)P(C \cos \theta) dt \]

Outgoing light

- Light reflected in view direction from light source
- Incoming light filtered by the voxel
- Light emitted by the voxel

I(t)

Radiation from light source
Attenuated, shadowed by volume

Only needed where internal shadows are important e.g., clouds, fire, smoke
Ray casting algorithm

For every pixel in output image
- shoot ray into volume
- at evenly spaced ray locations, obtain color and opacity by interpolation
- merge color and opacities
  - front to back
  - back to front

Visualization pipeline

- Shade volume data
- compute local gradient -> voxel normal
- produce RGB intensity for every voxel
- determine opacity of each voxel
  - application dependent
  - e.g. X-ray absorption coefficient
- Ray cast volume

Voxel values

- C(X) - shade
- a(X) - opacity
- Cout = Cin(1-a(Xi))+c(Xi)a(Xi)

Often parallel projection is used to simplify calcs

Packages

- AVS: Application Visualization System
- IBM Data Explorer (DX)
- Data Visualizer
Display issues

How to represent:
- Temporal information
- Non-spatial information
- Multi-dimensional information

Examples

Examples

Examples

Examples
Examples

Speed-ups

- Hierarchical spatial enumeration
- Adaptive termination

Hierarchical Spatial Enumeration

Traversing Volume