Accelerating Volume Rendering

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Ray casting
- **Alpha-cutoff**
- **Space leaping**

Splatting
- **Hierarchical splatting**
- **Texture splats**

Parallel algorithms
- **Screen-space subdivision**
- **Object-space subdivision**

3D texture mapping
- **Transparent textures**
- **Shaded isosurfaces**

Video

State et al., "Interactive Volume Visualization on a Heterogeneous Message-Passing Multicomputer," *Proceedings of the 1995 Symposium on Interactive 3D Graphics.*

Texture Splats

- Uses texture hardware to apply contribution of each voxel to pixels
- Precompute splat kernel texture
- For each voxel plane (front-to-back)
  - For each voxel
    - Translate textured polygon
    - Set rgba according to voxel
    - Render textured polygon

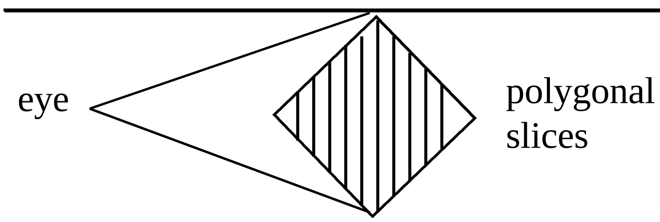
3D Texture Map Approach

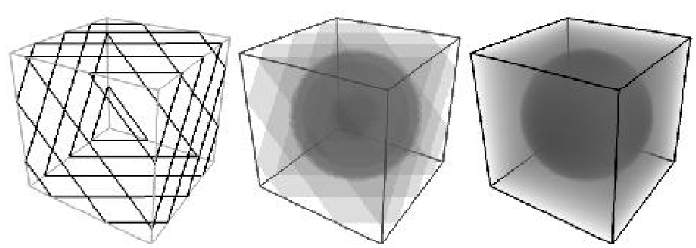
Load volume data into 3D texture hardware

Generate set of slice polygons parallel to viewing plane

Render slices with 3D texture coordinates in front-to-back order

Transparent Textures Illustration





from Westermann and Ertl, “Efficiently Using Graphics Hardware in Volume Rendering Applications, *Proceedings of SIGGRAPH 98*, page 170.

Johns Hopkins Department of Computer Science
Course 600.456: Rendering Techniques, Professor: Jonathan Cohen

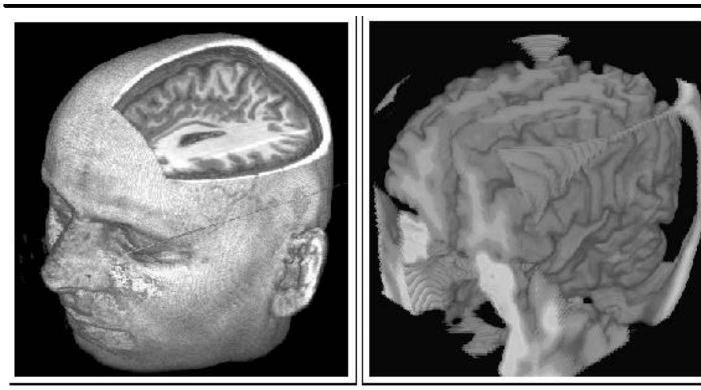
Clipping Volumes

Useful for getting clear view of interior structures

More general than just clipping planes

Possible using pixel-operations on each slice

Clipping Box Examples



(a) Box clipping performed with the stencil buffer.

(b) Inverse box clipping of the brain.

from Westermann and Ertl, “Efficiently Using Graphics Hardware in Volume Rendering Applications, *Proceedings of SIGGRAPH 98*, page 177.

Clipping with the Stencil Buffer

Allow any closed, polygonal clip volume

Slice needs to be culled to pixels inside clip volume

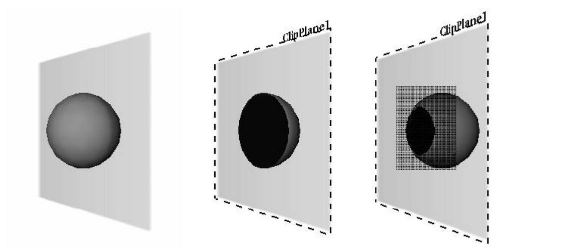
Align clipping plane (near plane) with slice

Render clip volume into z- and stencil-buffers

- **Back-facing polygons set stencil buffer**
- **Front-facing polygons clear stencil buffer**

Render slice with stencil-buffer test enabled

Clipping Volume Diagram



from Westermann and Ertl, "Efficiently Using Graphics Hardware in Volume Rendering Applications, *Proceedings of SIGGRAPH 98*, page 177.

Figure 2: The use of arbitrary clipping geometries is demonstrated for the case of a sphere. In regions where the object intersects the actual slice the stencil buffer is locked. The intuitive approach of rendering only the back faces might result in the patterned erroneous region.

On the plane, pixels where we see the interior of the clip volume should leave the stencil buffer set, so those pixels of the volume are rendered.

Direct Iso-surface Rendering

Advantages

- **Avoids generation of polygonal representation**
- **Allows interactive setting of threshold value**

Store volume values in alpha component

Enable alpha test to only render slice pixels with alpha >= threshold

Also enable z test so only first such value is rendered

Iso-surface Shading

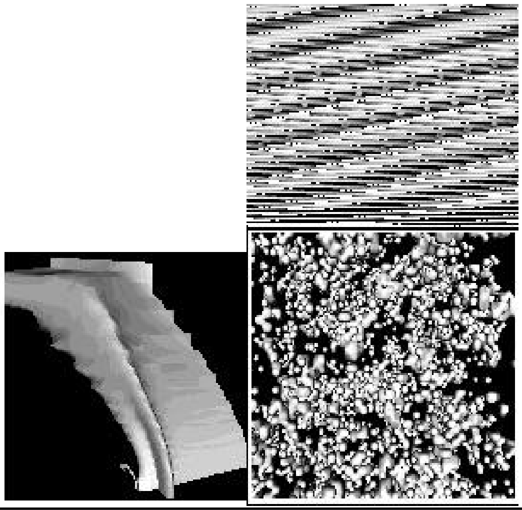
Store gradient + material value in another 3D rgba texture

Render iso-surface from gradient texture

Apply directional light using color matrix multiplication (copy buffer onto itself)

Build normal transformation into the same matrix

Shaded Iso-surface Examples



from Westermann and Ertl, “Efficiently Using Graphics Hardware in Volume Rendering Applications, *Proceedings of SIGGRAPH 98*, page 177.