



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

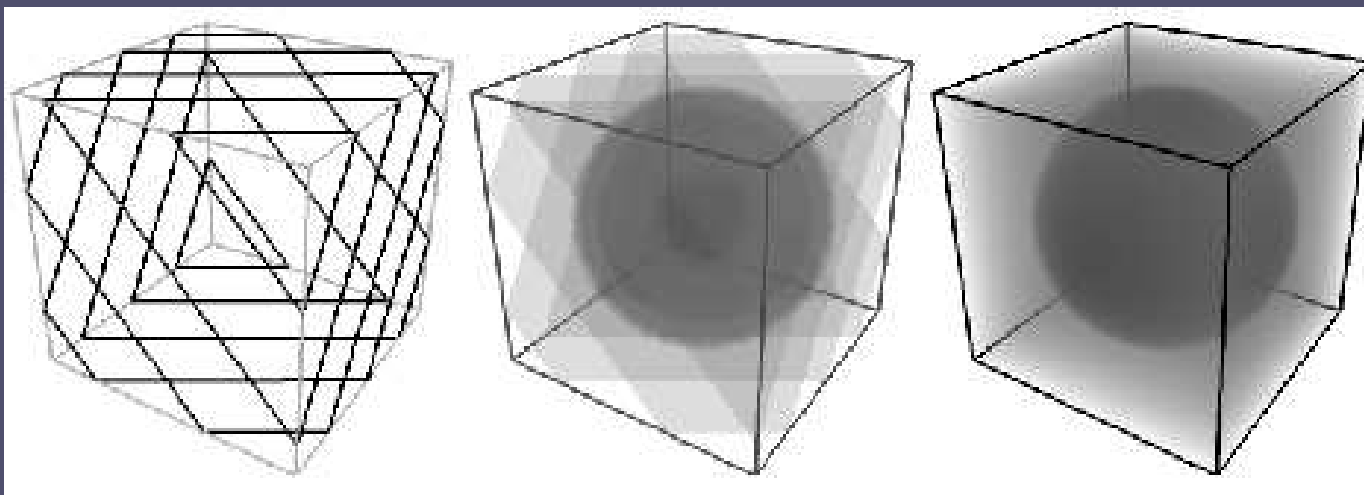
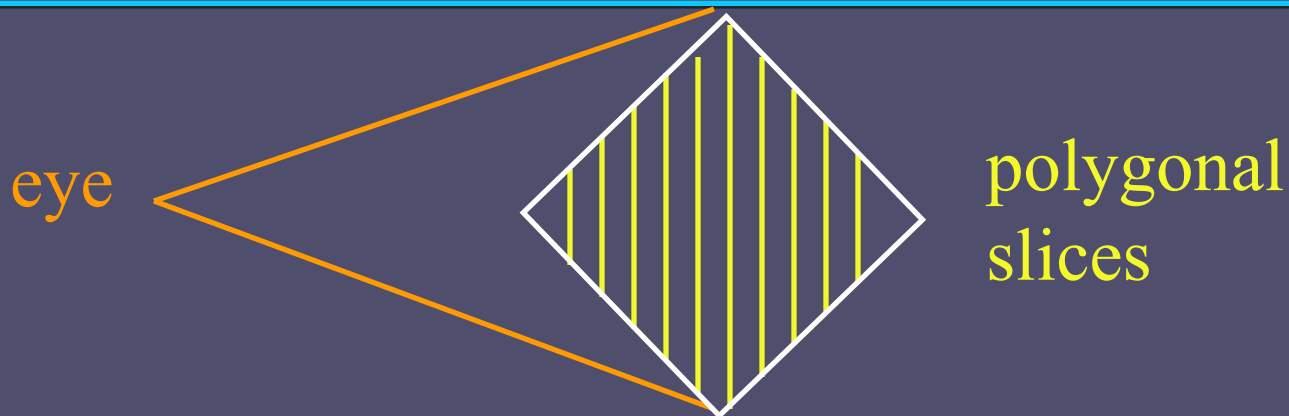
Load volume data into 3D texture hardware

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.



Clipping Volumes

Useful for getting clear view of interior structures

More general than just clipping planes

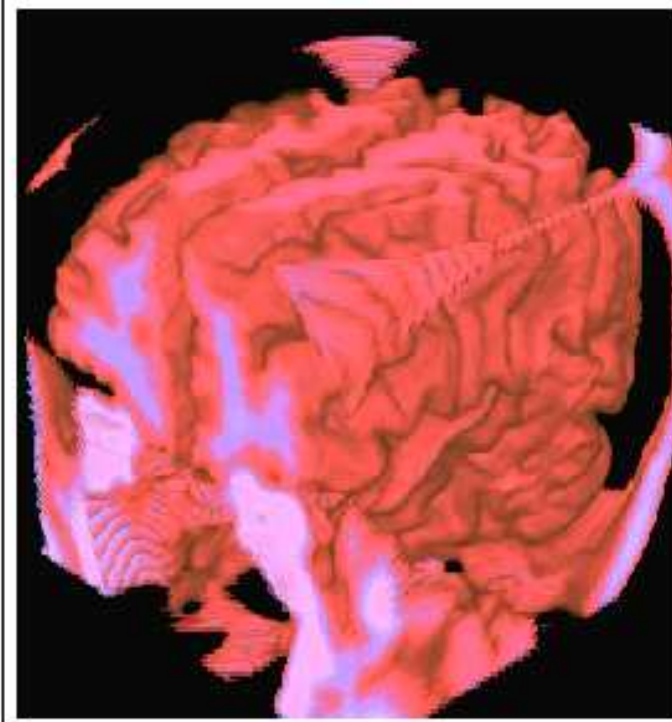
Possible using pixel-operations on each slice



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

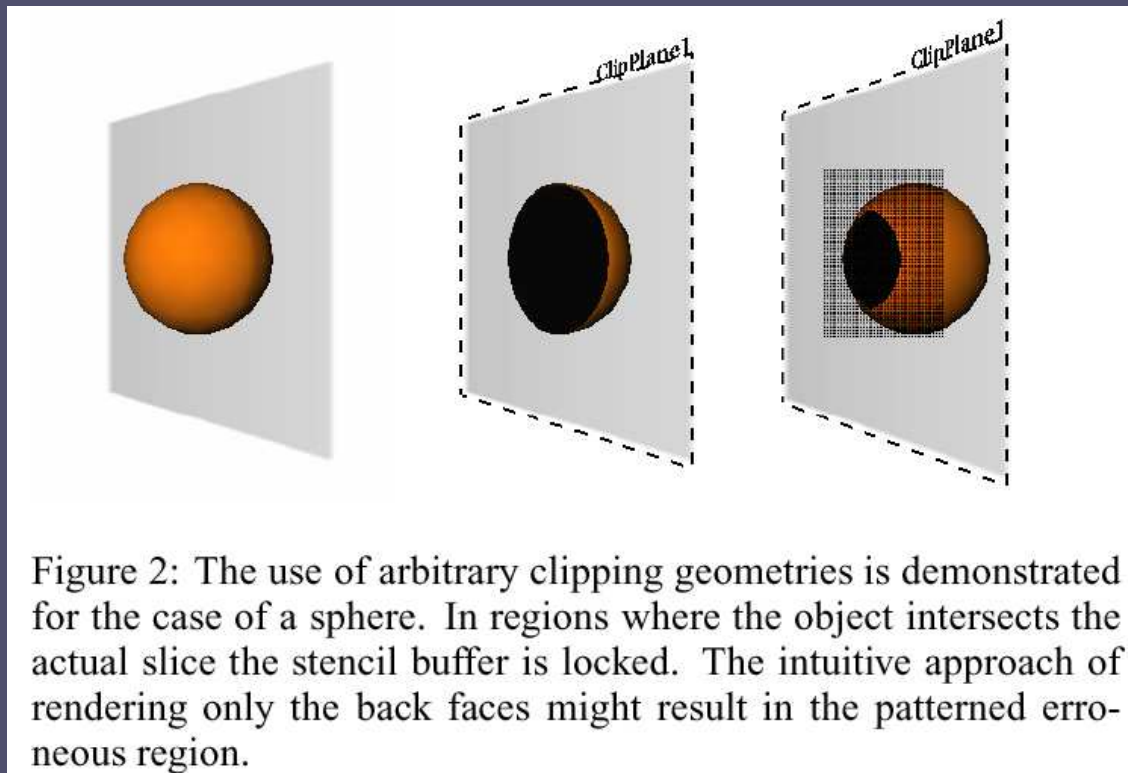


Figure 2: The use of arbitrary clipping geometries is demonstrated for the case of a sphere. In regions where the object intersects the actual slice the stencil buffer is locked. The intuitive approach of rendering only the back faces might result in the patterned erroneous region.

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

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 $\alpha \geq \text{threshold}$

Also enable z test so only first such value is rendered



Iso-surface Shading

**Store gradient + material value in another
3D rgba texture**

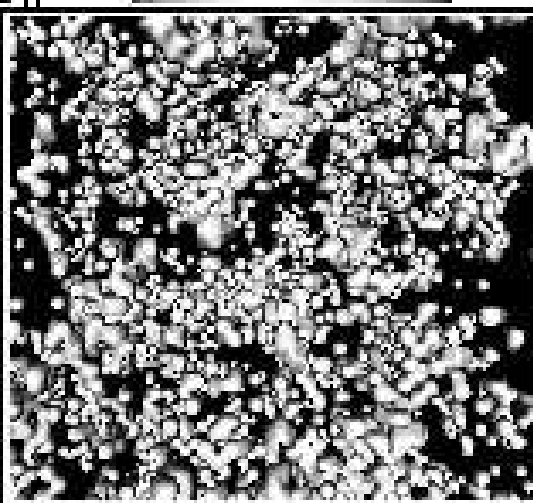
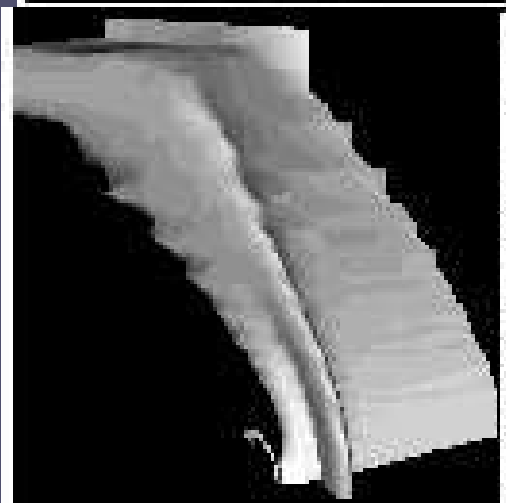
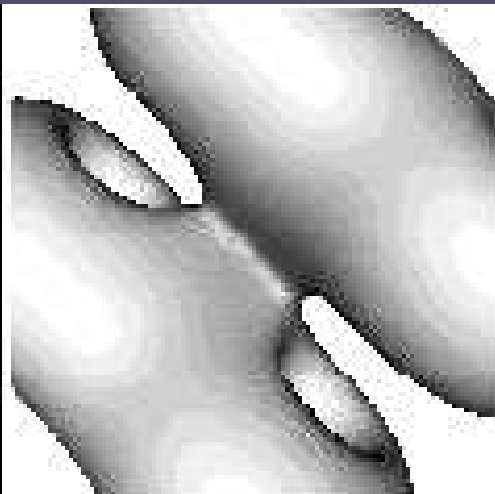
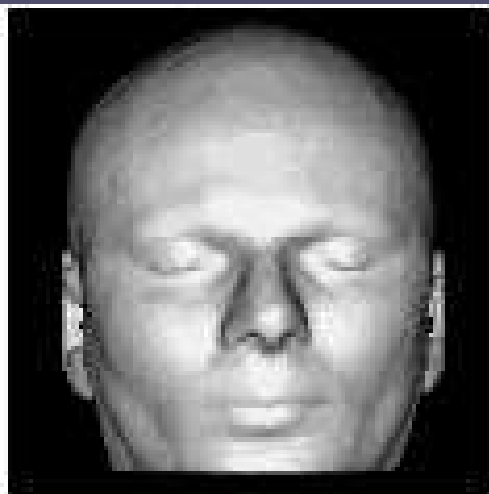
Render iso-surface from gradient texture

**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.