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**
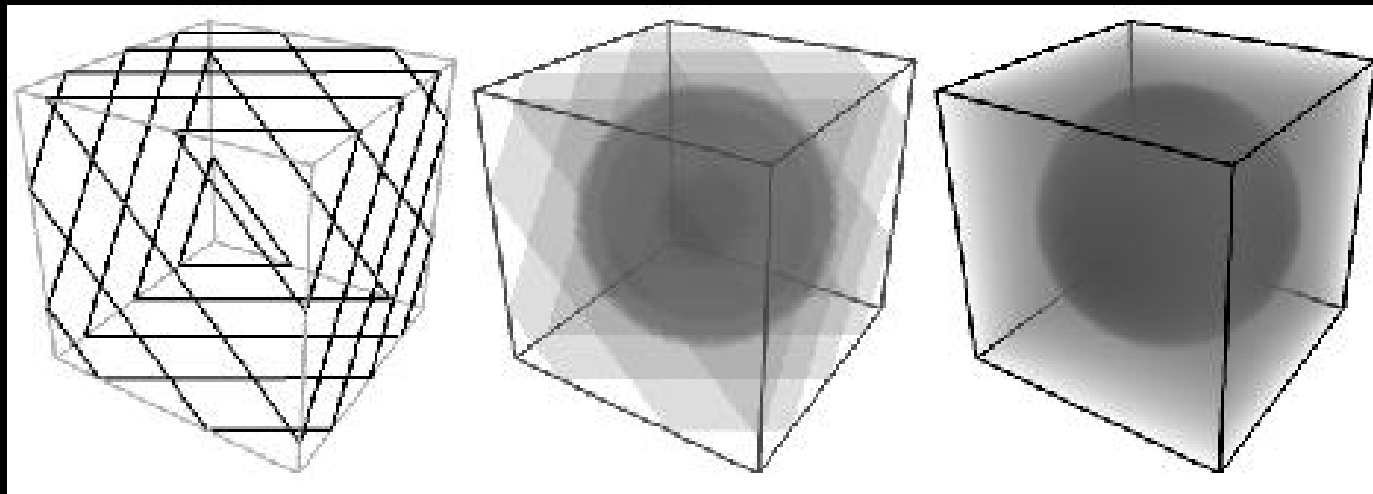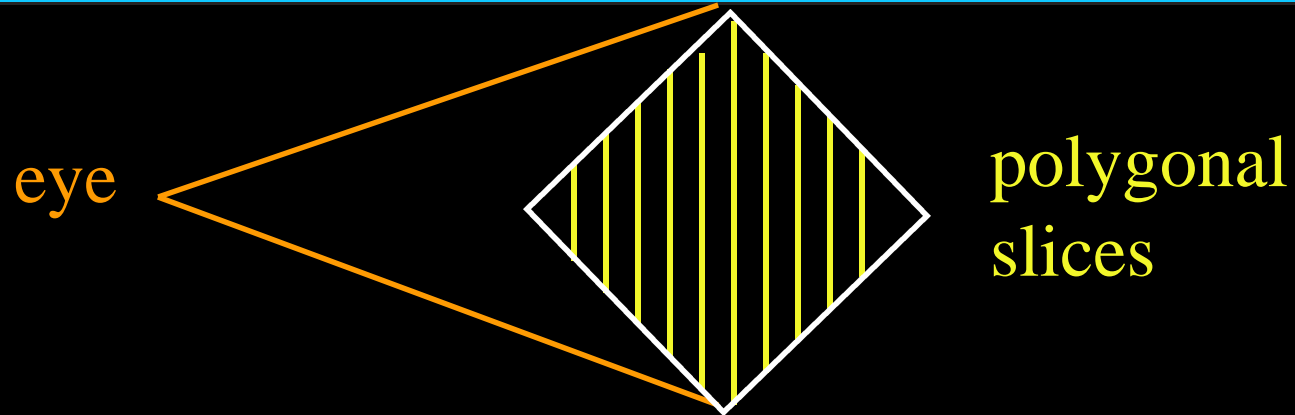
3D Texture Map Approach

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

eye

polygonal slices

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
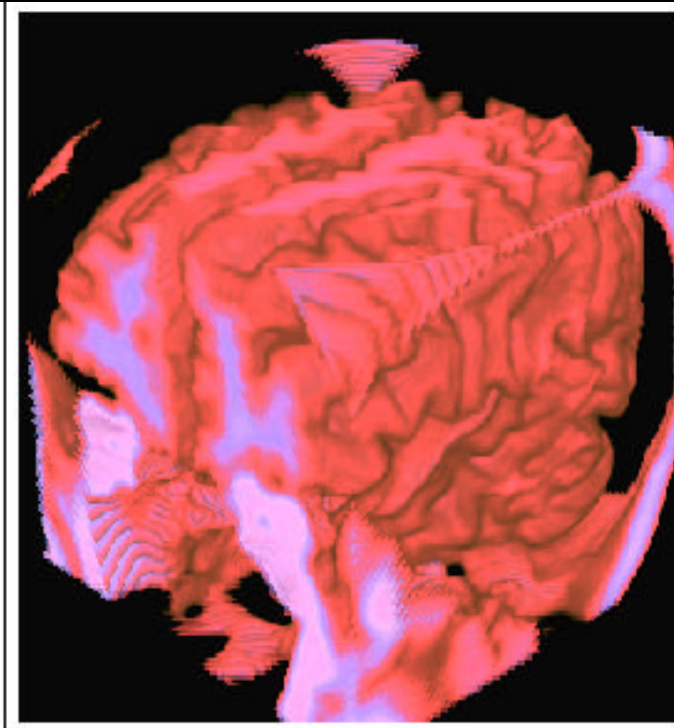
More general than just clipping planes

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

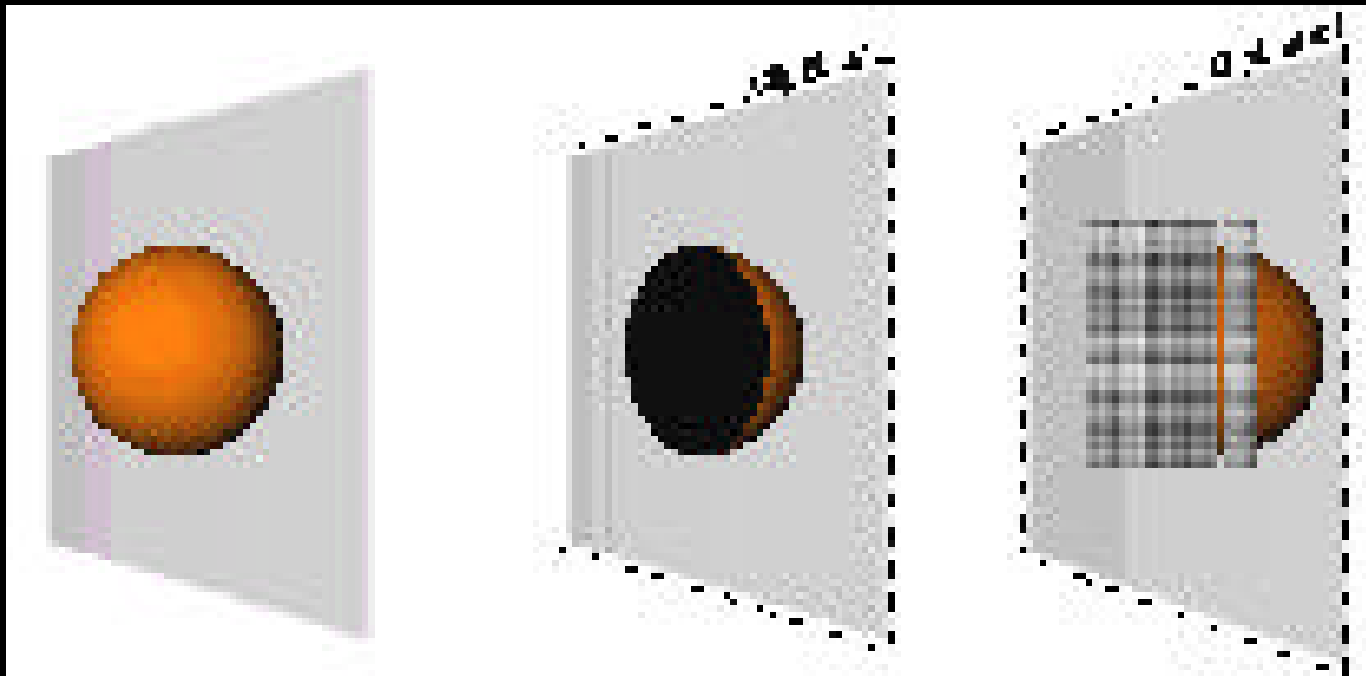Align clipping plane (near plane) with slice

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

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 >= threshold

Also enable z test so only first such value is rendered

Iso-surface Shading
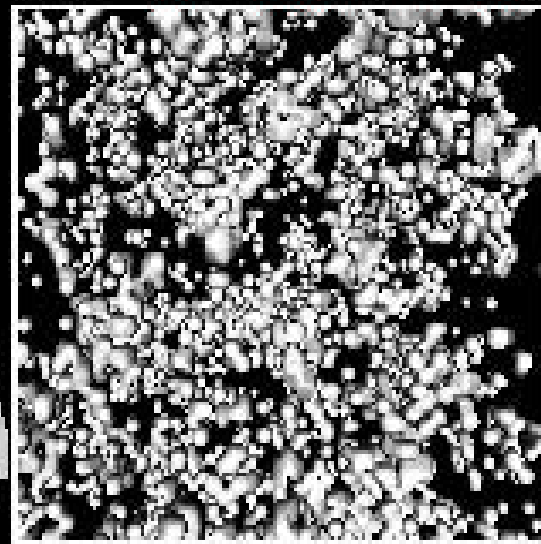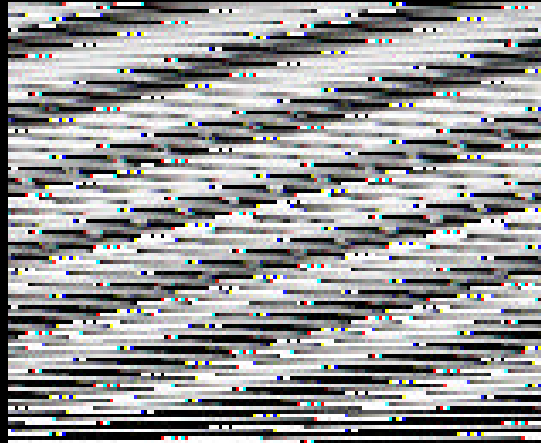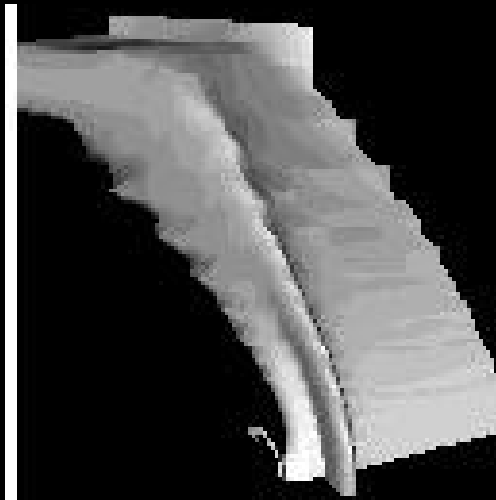
Store gradient + material value in another 3D rgba texture

Render iso-surface from gradient texture

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

Build normal transformation into the same matrix

Iso-surface Examples

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