CSE 167:
Introduction to Computer Graphics
Lecture #17: Volume Rendering

Jürgen P. Schulze, Ph.D.
University of California, San Diego

Fall Quarter 2010

Announcements

- Second midterm grades on-line
  - 1st Midterm: min 28, max 85, average 59
  - 2nd Midterm: min 42, max 95, average 68
- Please check Gradesource for accuracy. Everything but the final project should be there.
- Final project to be presented on **Friday, Dec 3rd, between 2 and 4pm in room 4140**
  - No late submissions accepted

Lecture Overview

- Midterm Review
- Volume Rendering

Lecture Overview

- Midterm Review
- Volume Rendering

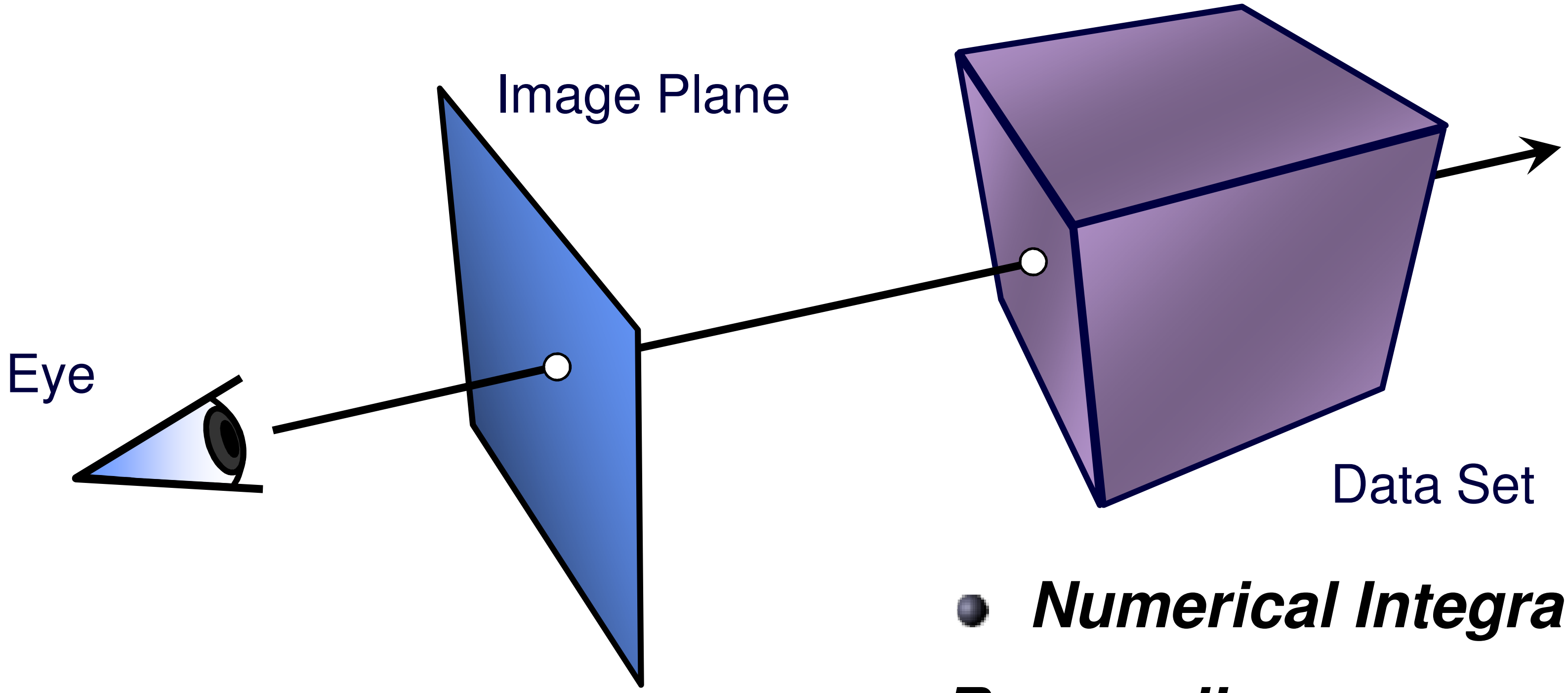
Rendering Methods

There are two categories of volume rendering algorithms:

1. Ray casting algorithms (Object Order)
   - Basic ray-casting
   - Using octrees
2. Plane Composing (Image Order)
   - Basic slicing with 2D textures
   - Shear-Warp factorization
   - Translucent textures with image-aligned 3D textures

Ray Casting

- Software Solution

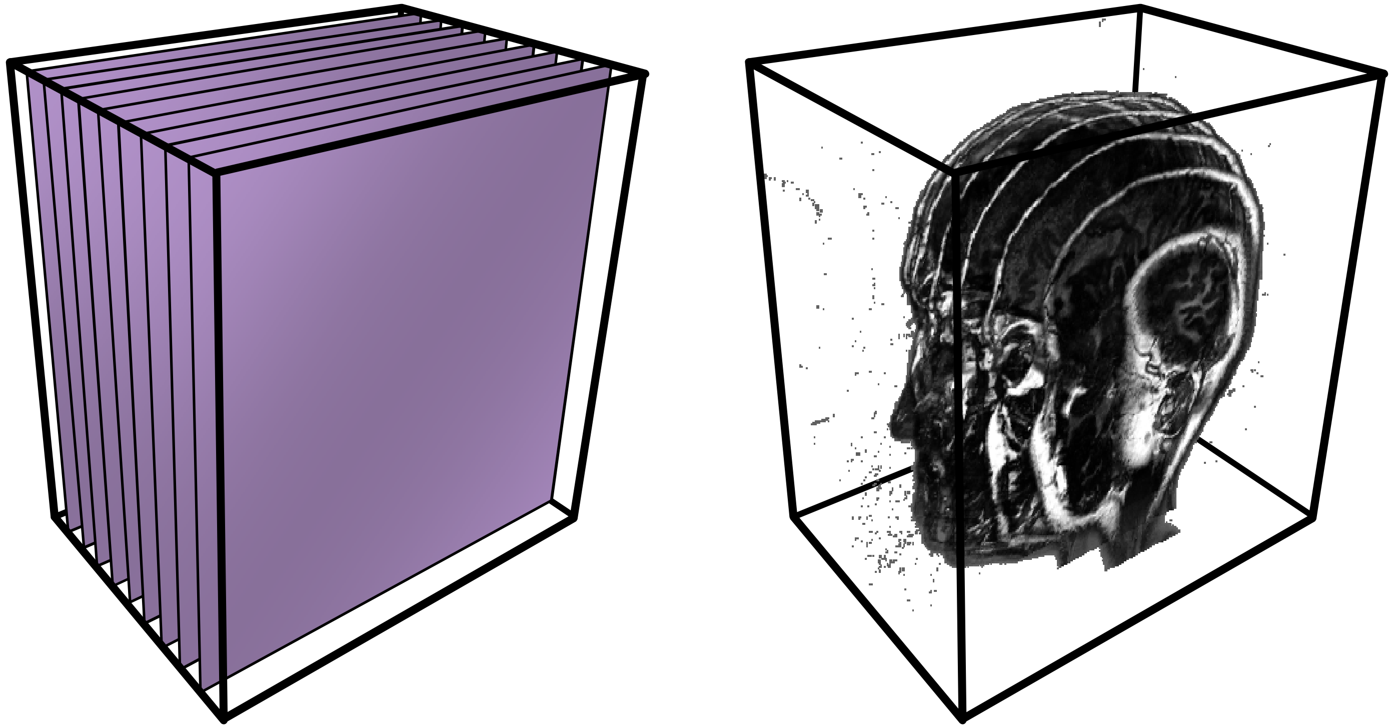


- ***Numerical Integration***
- ***Resampling***

⇨ ***High Computational Load***

Plane Compositing

- Proxy geometry (Polygonal Slices)

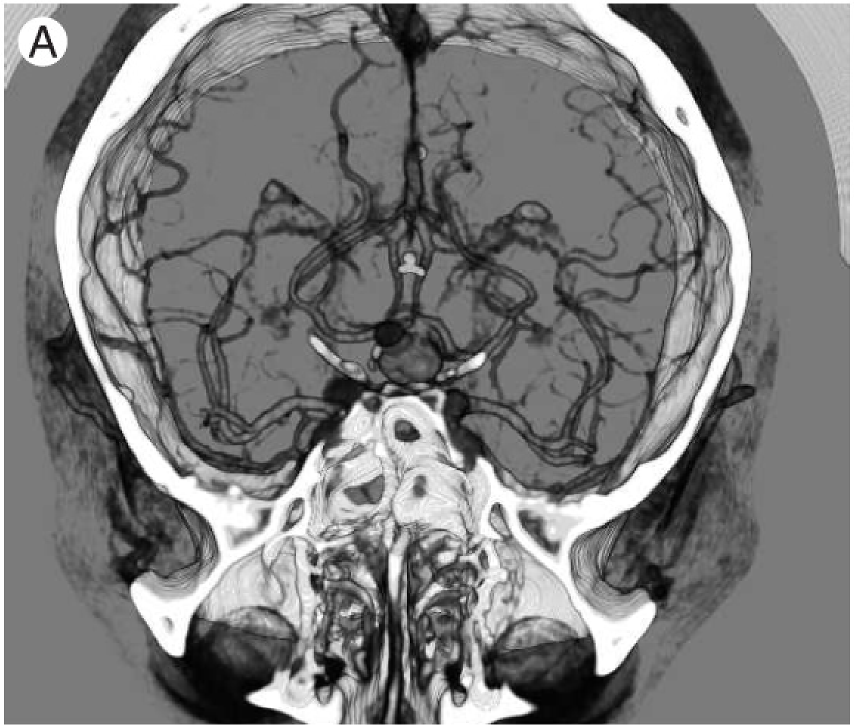


Compositing

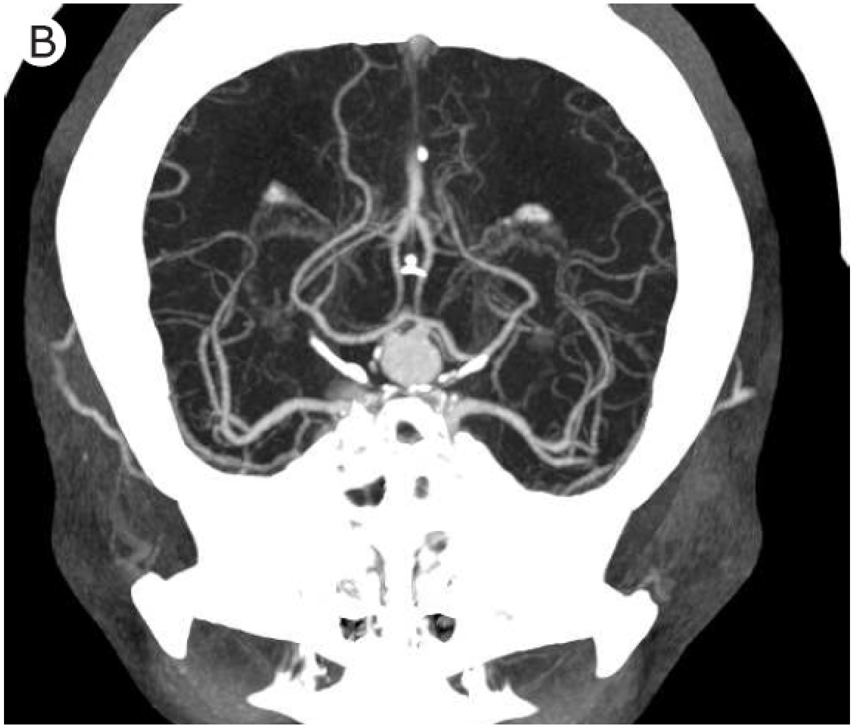
- ***Maximum Intensity Projection***

  No emission/absorption

  Simply compute maximum value along a ray



Emission/Absorption

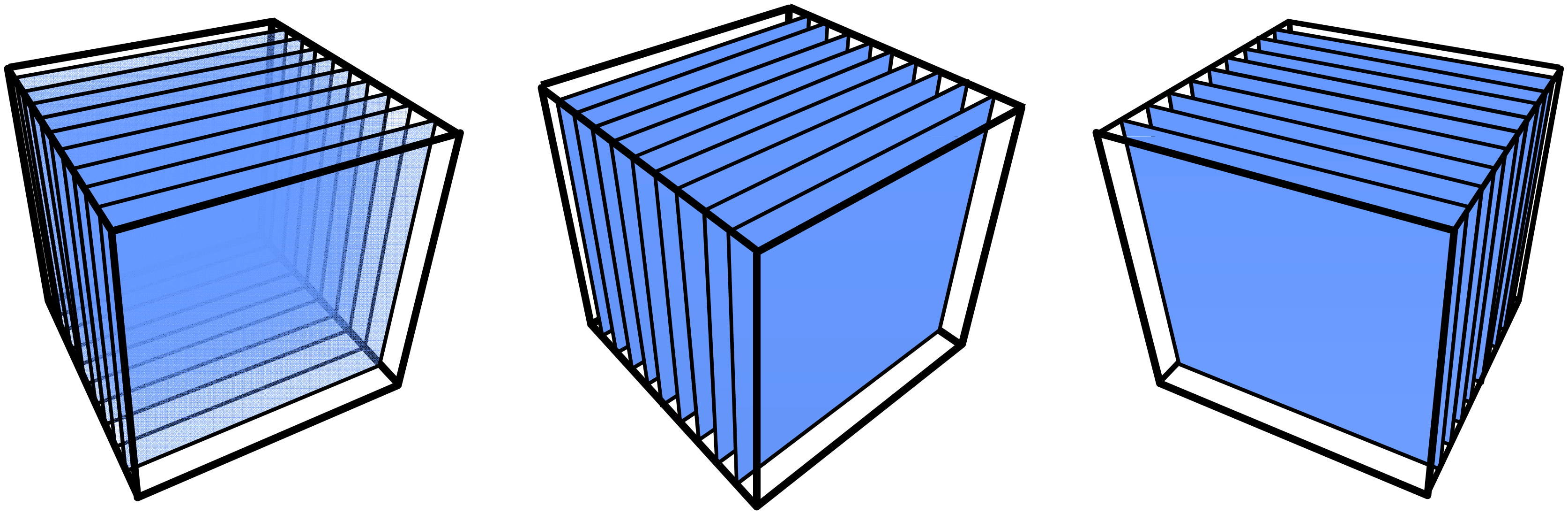


Maximum Intensity Projection

2D Textures

- Draw the volume as a stack of 2D textures
  Bilinear Interpolation in Hardware

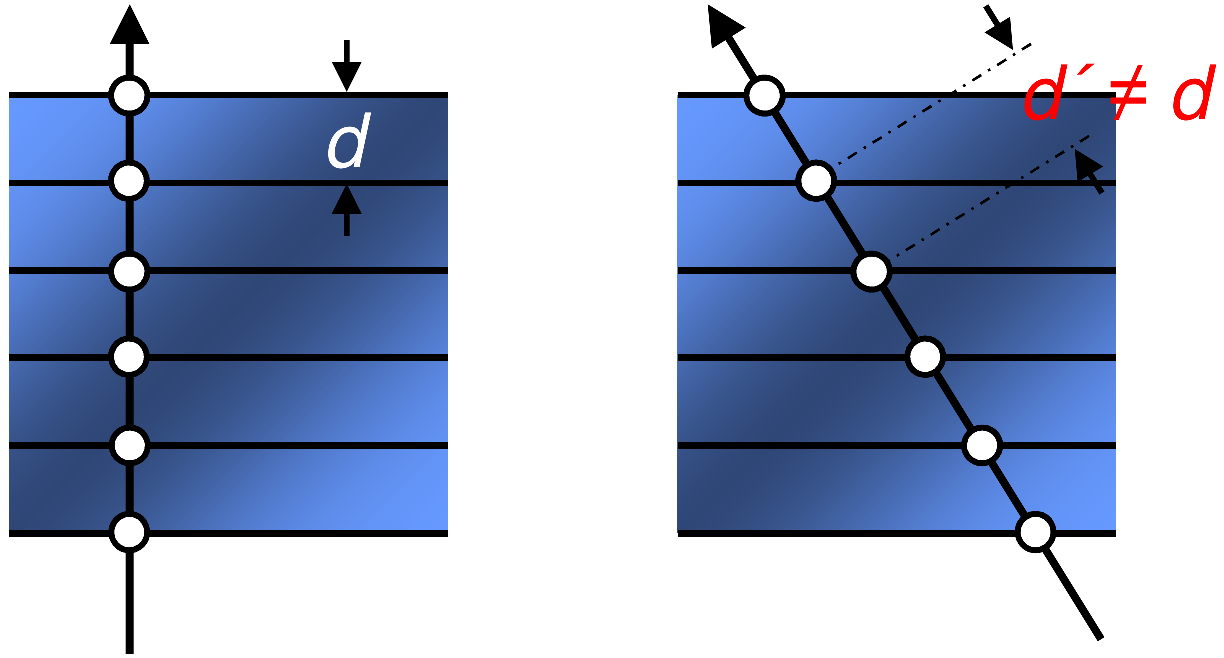
➡ Decompostition into axis-aligned slices



- 3 copies of the data set in memory

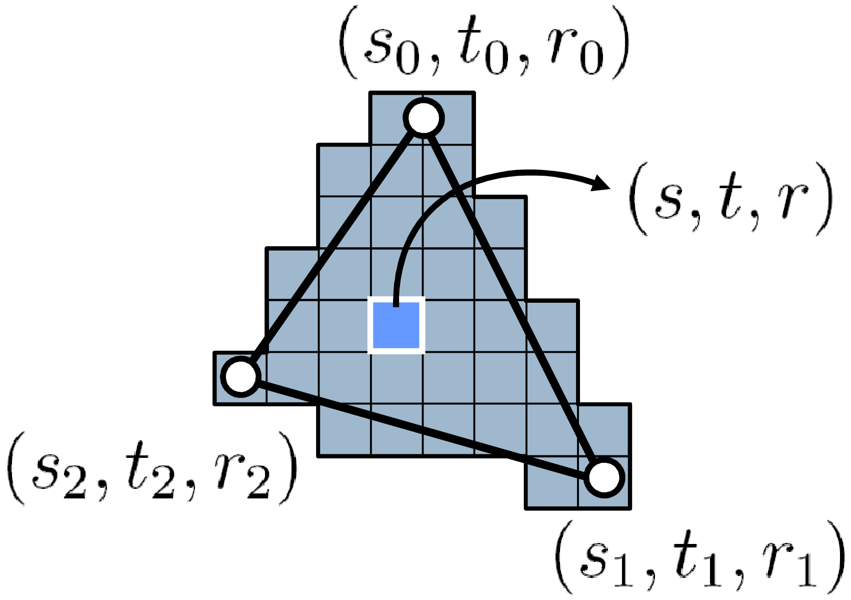
2D Textures: Drawbacks

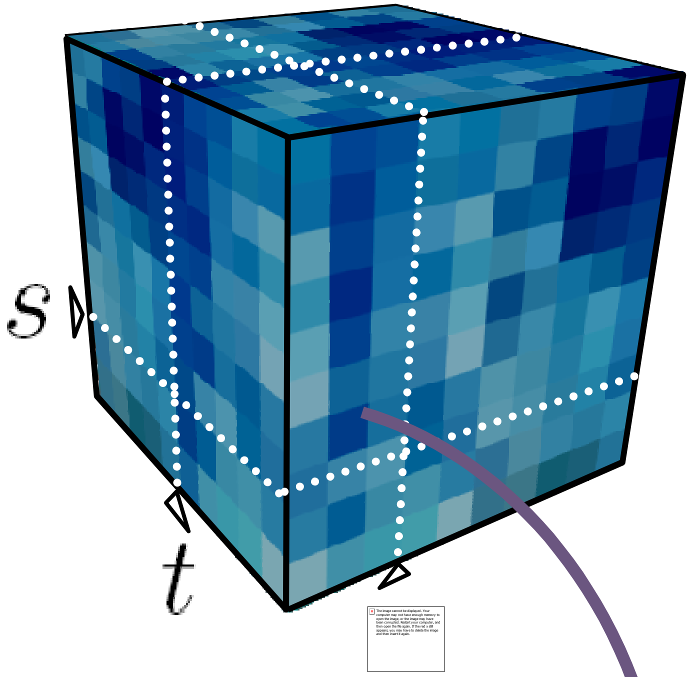
- Sampling rate is inconsistent



- Emission/absorption slightly incorrect
- ***Super-sampling on-the-fly impossible***

3D Textures





For each fragment:
interpolate the
texture coordinates
(barycentric)

Texture-Lookup:
interpolate the
texture color
(trilinear)

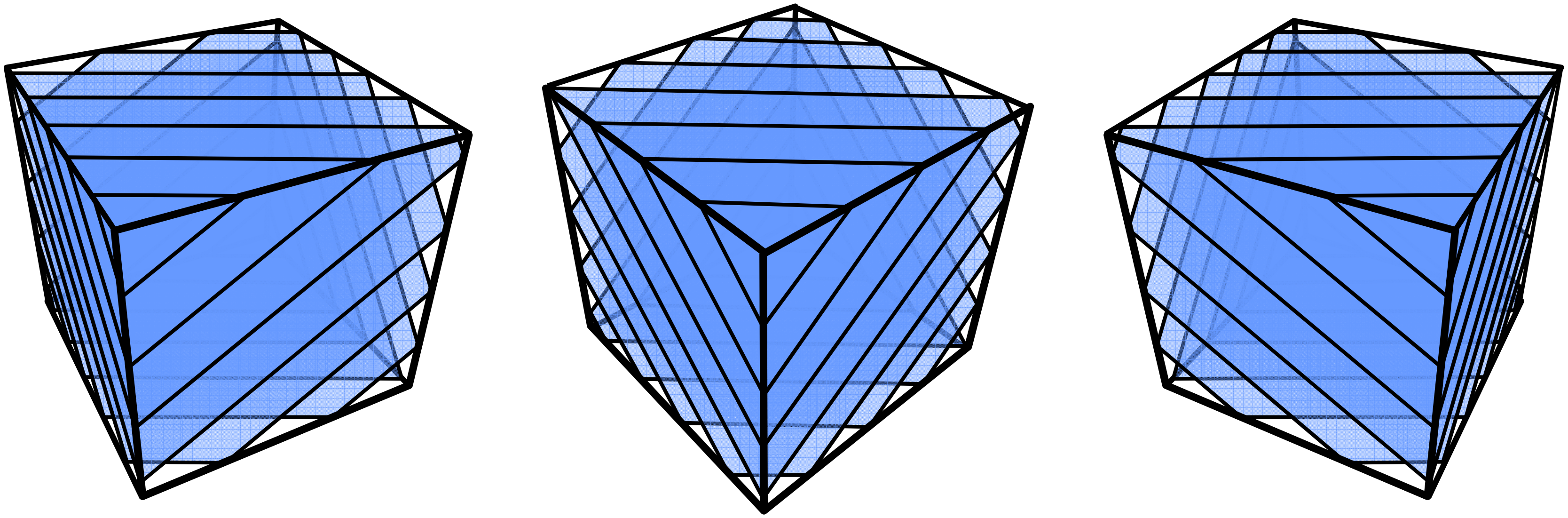
RGBA

3D Textures

3D Texture: Volumetric Texture Object

- Trilinear Interpolation in Hardware

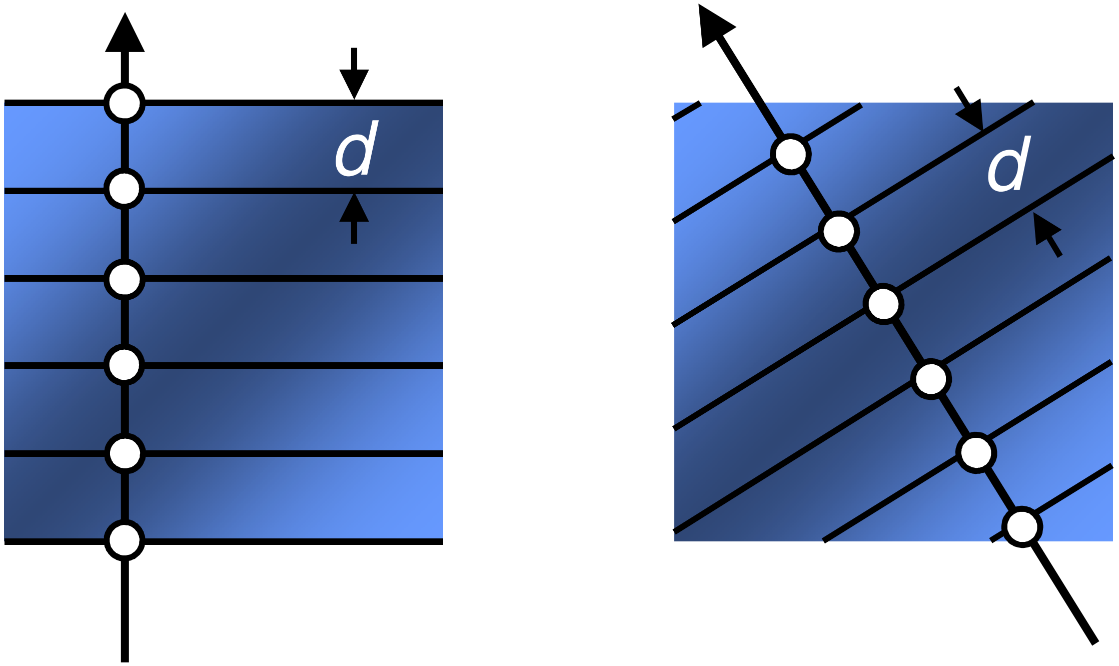
➡ Slices parallel to the image plane



- One large texture block in memory

Resampling via 3D Textures

- ***Sampling rate is constant***



- Supersampling by increasing the number of slices

Cube-Slice Intersection

Question: Can we compute this in a vertex program?

Vertex program:

Input: 6 Vertices

Output: 6 Vertices

━━ P0: Intersection with red path

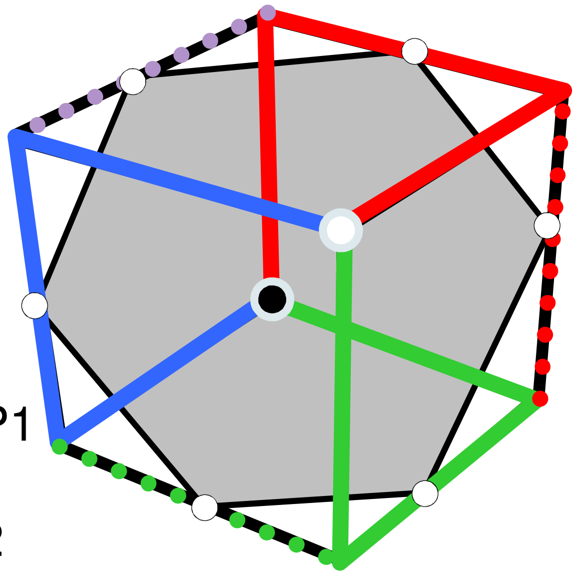
• • • • P1: Intersection with dotted red edge or P0

━━ P2: Intersection with green path

• • • • P3: Intersection with dotted green edge or P1

━━ P4: Intersection with blue path

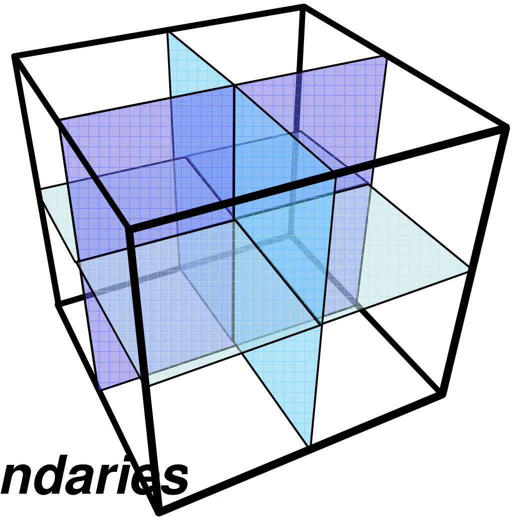
• • • • P5: Intersection with dotted blue edge or P2



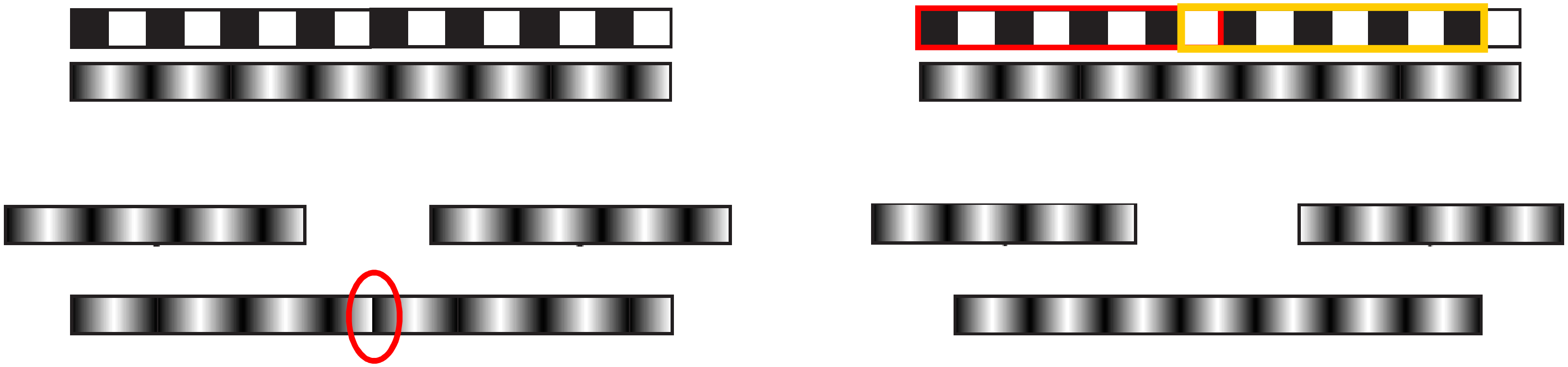
Bricking

- What happens if data set is too large to fit into local video memory?

➡ Divide the data set into smaller chunks (bricks)



One plane of voxels must be duplicated to enable correct interpolation across brick boundaries



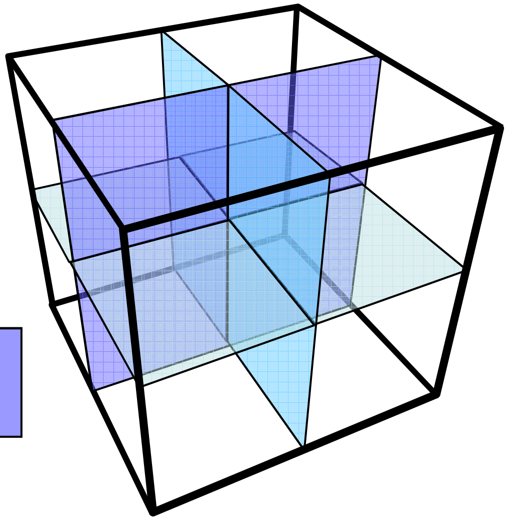
incorrect interpolation!

Bricking

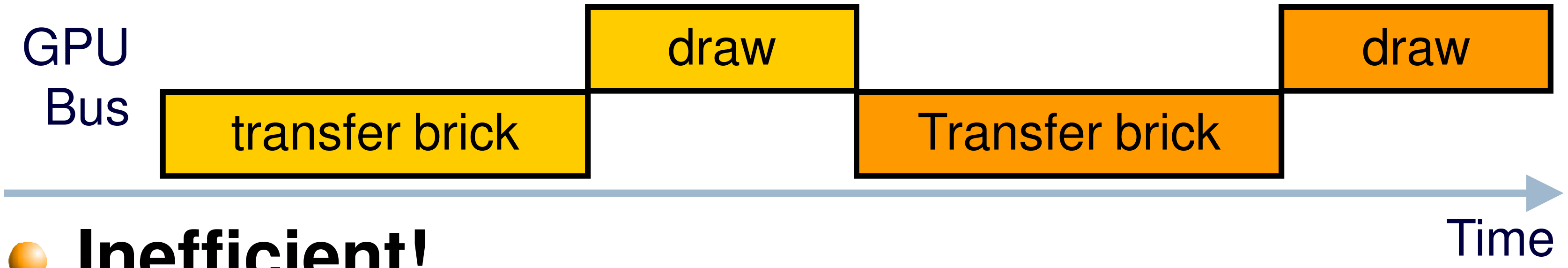
- What happens if data set is too large to fit into local video memory?

⇨ Divide the data set into smaller chunks (bricks)

Problem: Bus-Bandwidth



- Unbalanced Load for GPU und Memory Bus

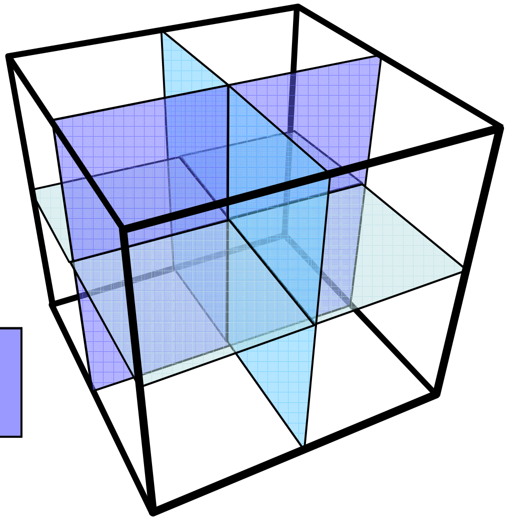


- **Inefficient!**

Bricking

- What happens if data set is too large to fit into local video memory?

⇨ Divide the data set into smaller chunks (bricks)



Problem: Bus-Bandwidth

- Keep the bricks small enough!
  More than one brick must fit into video memory !
  - Transfer and Rendering can be performed in parallel
  - Increased CPU load for intersection calculation!
  - ***Effective load balancing still very difficult!***

Videos

- Human head, rendered with 3D texture: http://www.youtube.com/watch?v=94_Zs_6AmQw&feature=related
- GigaVoxels: http://www.youtube.com/watch?v=HScYuRhgEJw&feature=related
- Future Gaming Technology: http://www.youtube.com/watch?v=mySER0p9F64&feature=related

Thank You

- Good luck with your final project!
- Happy Holidays!
- Happy New Year!

- See you tomorrow at 2pm