King Abdullah University of Science and Technology

KAUST

CS 247 – Scientific Visualization
Lecture 18: Volume Rendering, Pt. 5

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Reading Assignment #10 (until Apr 19)

Read (required):

- Real-Time Volume Graphics, Chapter 10
  (Transfer Functions Reloaded)
- Paper:

  Joe Kniss, Gordon Kindlmann, Charles Hansen,

  Multidimensional Transfer Functions for Interactive Volume Rendering*, IEEE Transactions on Visualization and Comp. Graph. (TVCG) 2002*

  `https://ieeexplore.ieee.org/document/1021579`

Read (optional):

- Real-Time Volume Graphics, Chapter 14
  (Non-Photorealistic and Illustrative Techniques)

Quiz #2: Apr 19

Organization

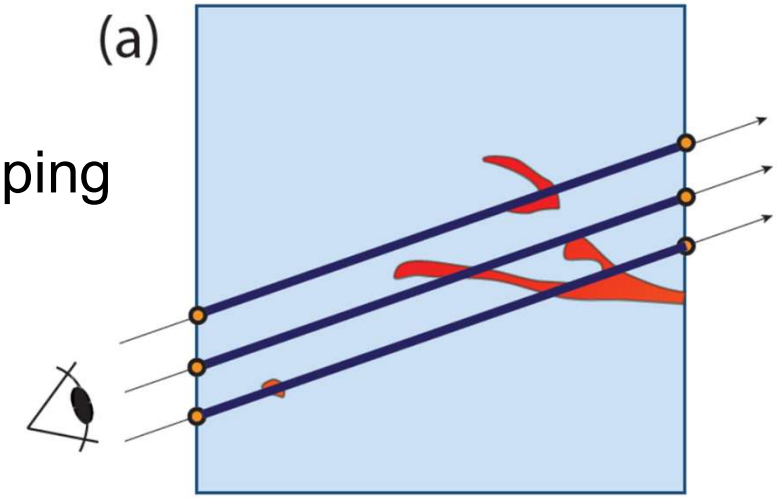
- First 30 min of lecture
- No material (book, notes, ...) allowed

Content of questions

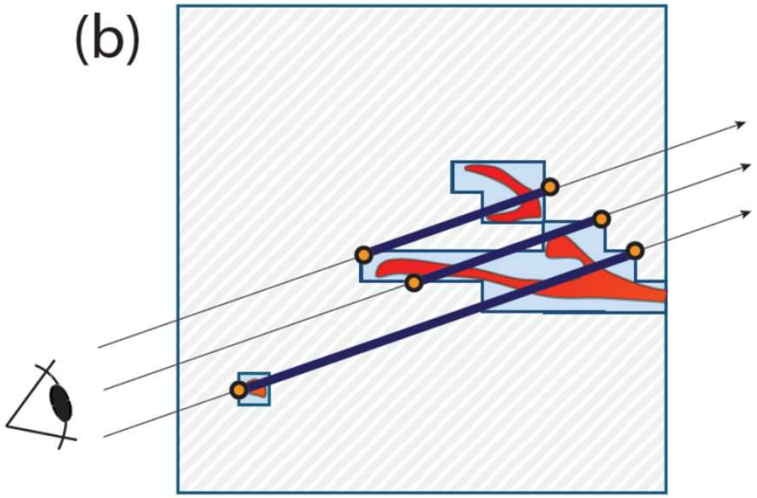
- Lectures (both actual lectures and slides)
- Reading assignments (except optional ones)
- Programming assignments (algorithms, methods)
- Solve short practical examples

Empty Space Skipping

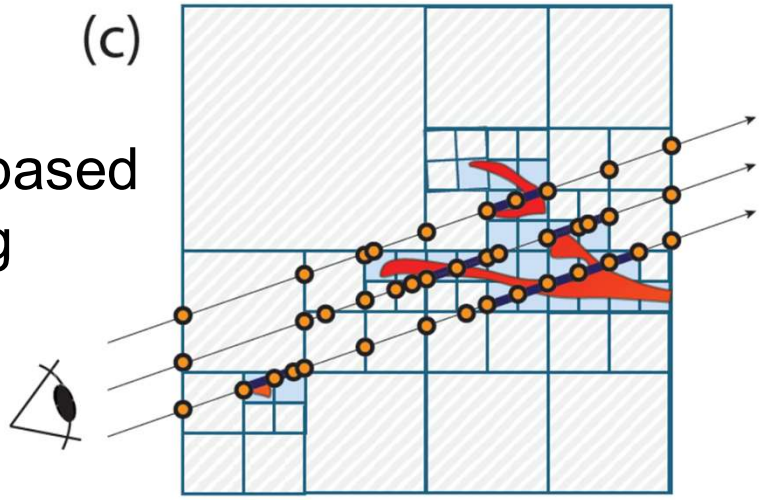
Different Approaches



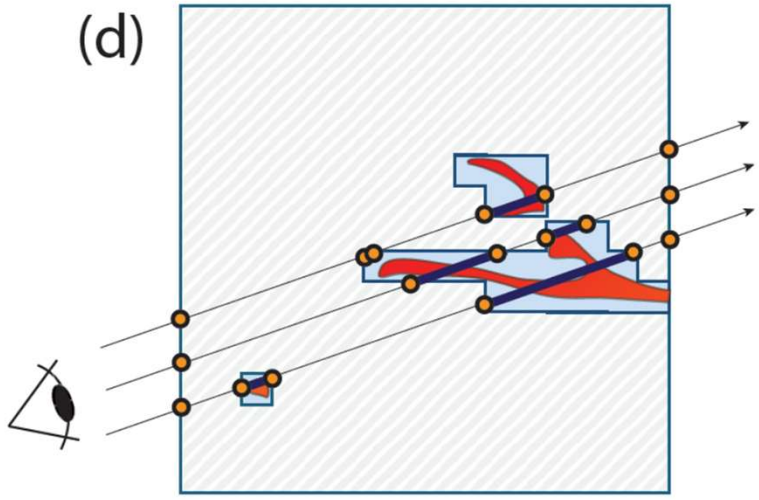
no skipping



simple object-order skipping



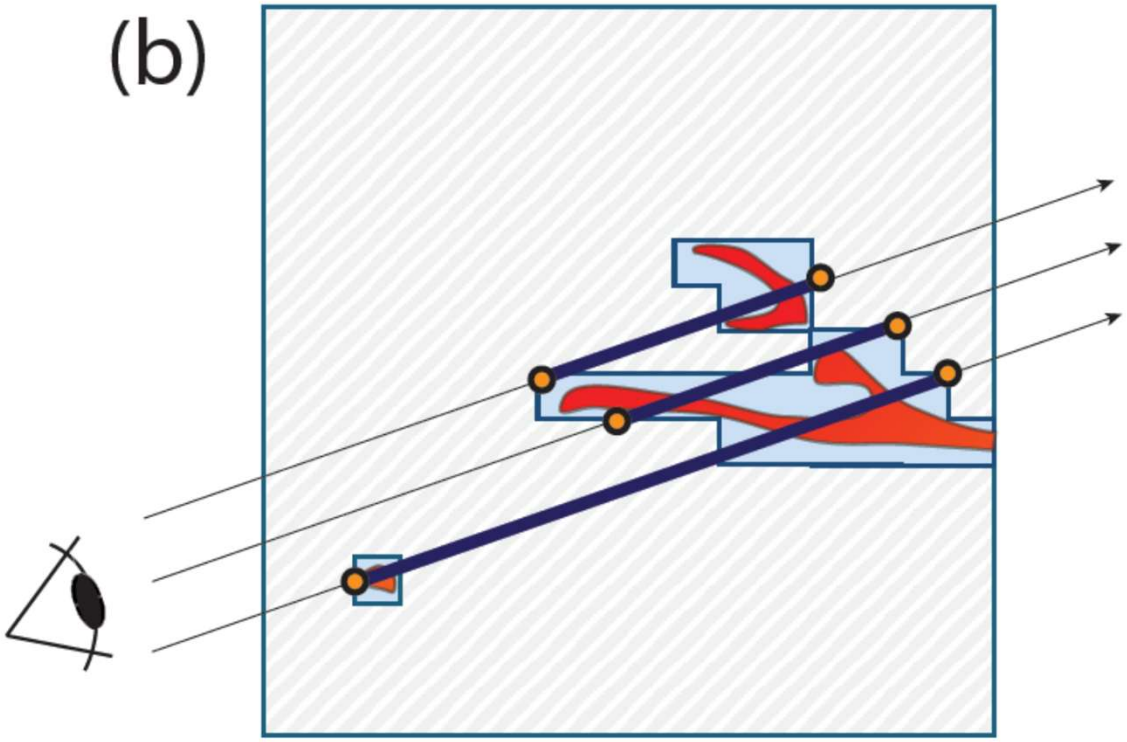
octree-based skipping



Sparse Leap

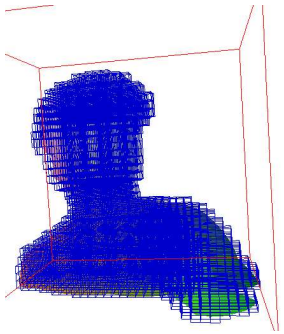
Object-Order Empty Space Skipping (1)

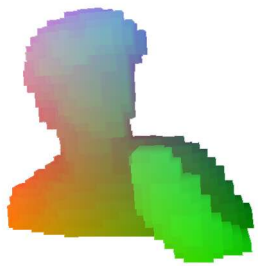
Modify initial rasterization step for ray setup

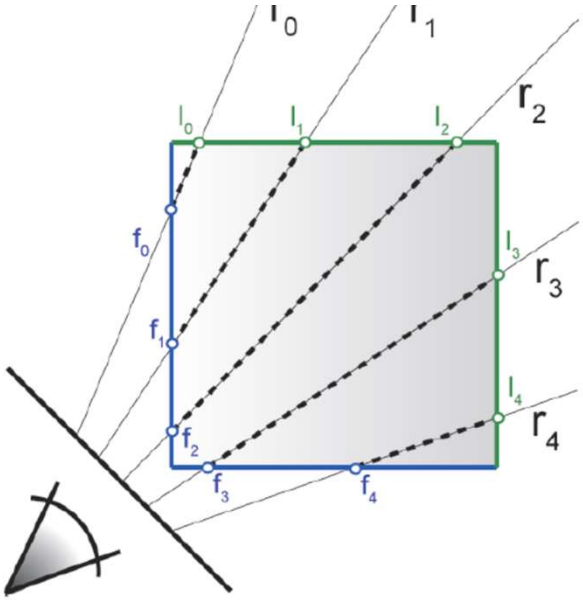


Object-Order Empty Space Skipping (2)

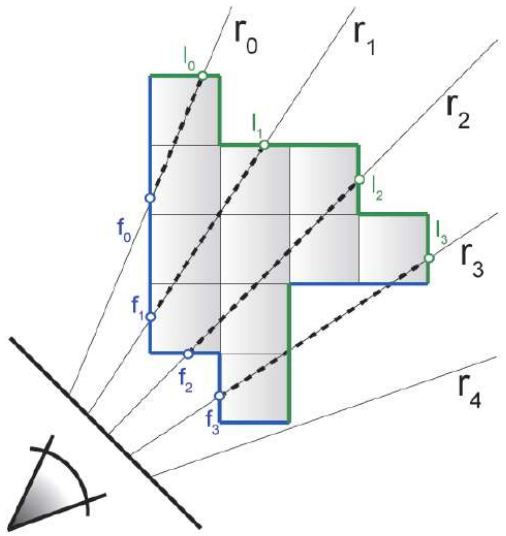
Modify initial rasterization step







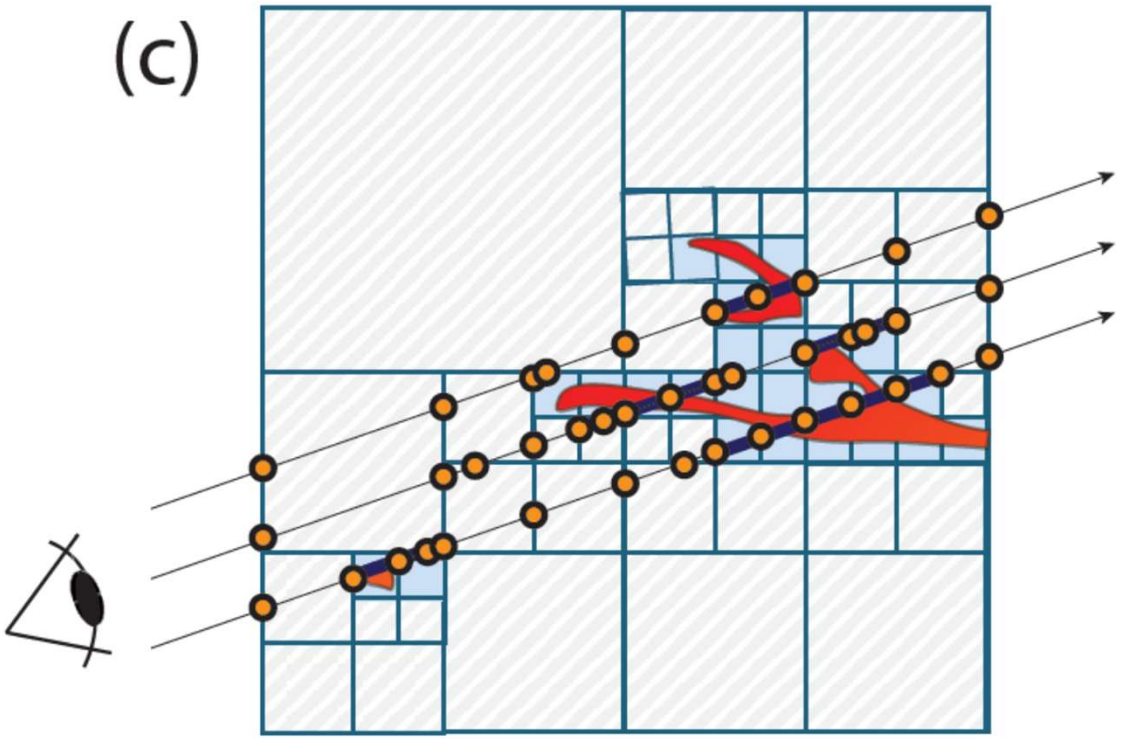
rasterize bounding box



rasterize “tight" bounding geometry

Octree-Based Empty Space Skipping

Everything is done during tree traversal along the ray



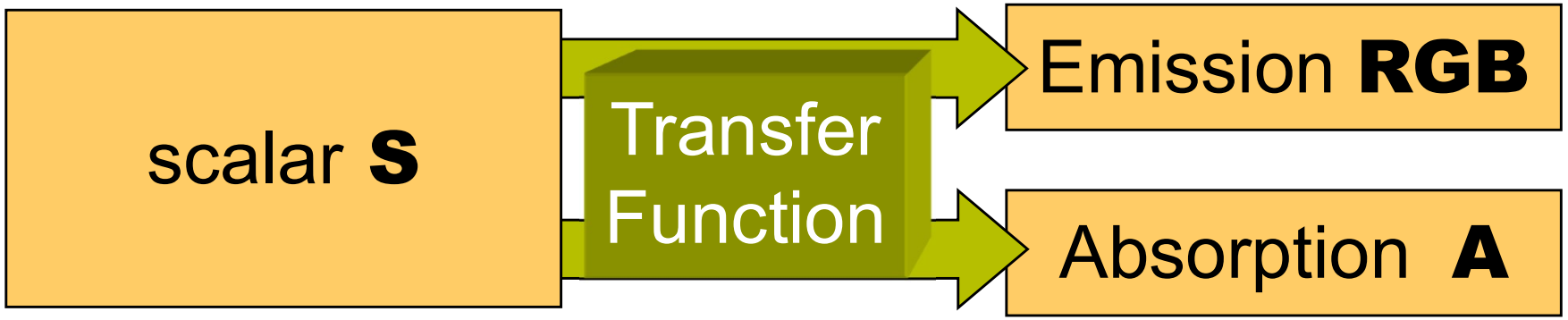
More on Transfer Functions

Classification – Transfer Functions

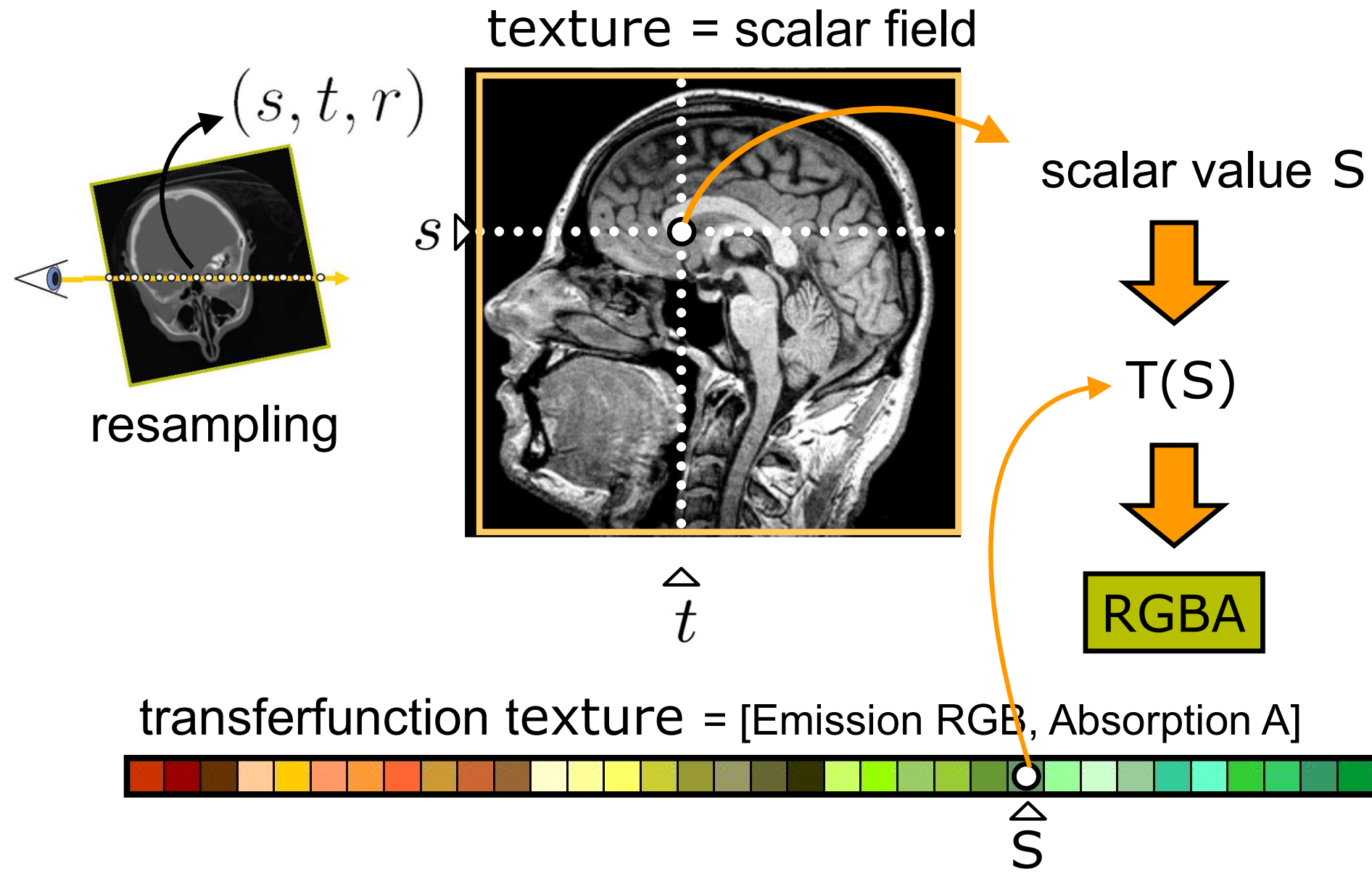
During Classification the user defines the ***"look"*** of the data.

- Which parts are transparent?
- Which parts have what color?

The user defines a ***transfer function.***



1D Transfer Functions



2D (or higher) Transfer Functions

Transfer function look-up with more than one attribute

- T(scalar value, ... additional attributes ...)

Additional attributes:

- Derivatives (most common: gradient magnitude)
- Segmentation information (integer label IDs)
- Curvature (of isosurface going through each point)
- Spatial position
- ...

2D (or higher) Transfer Functions

Derivatives indicate where material boundaries are located

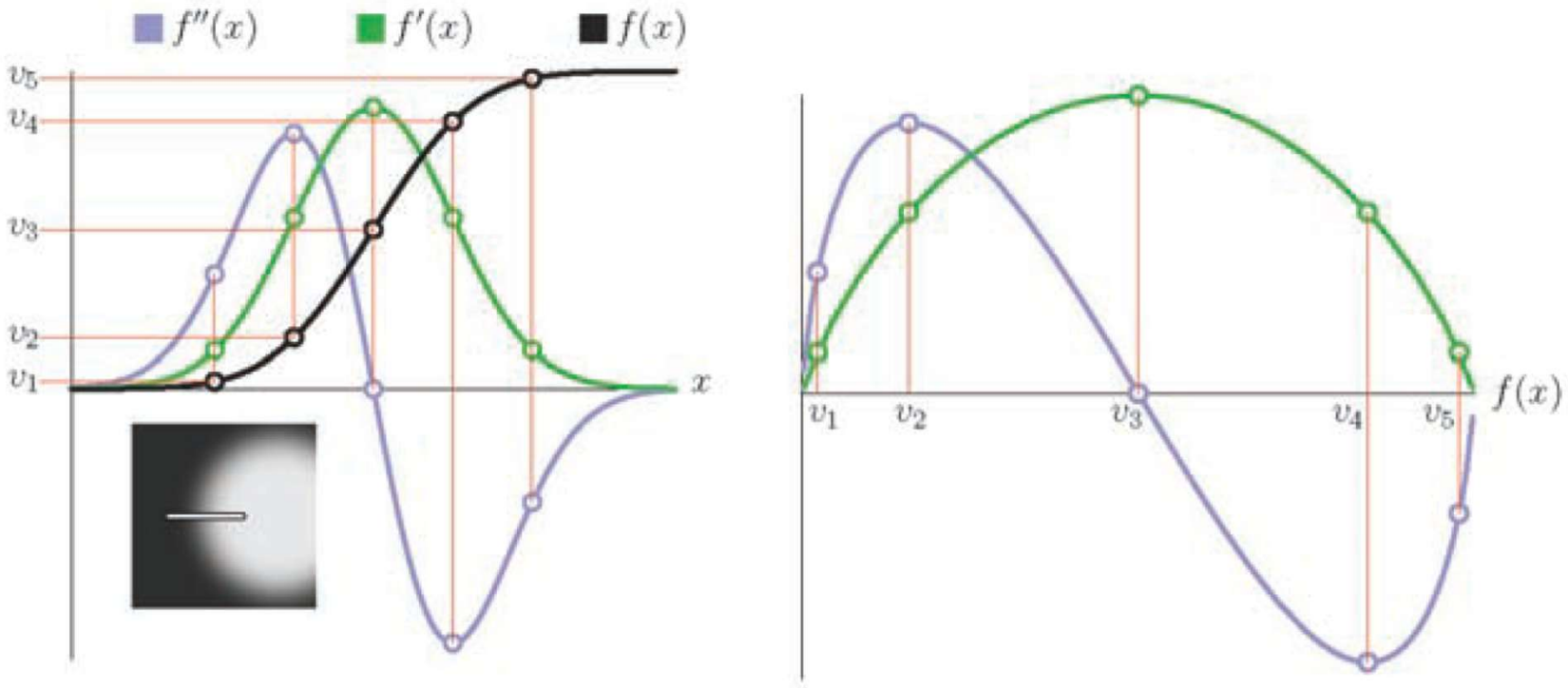


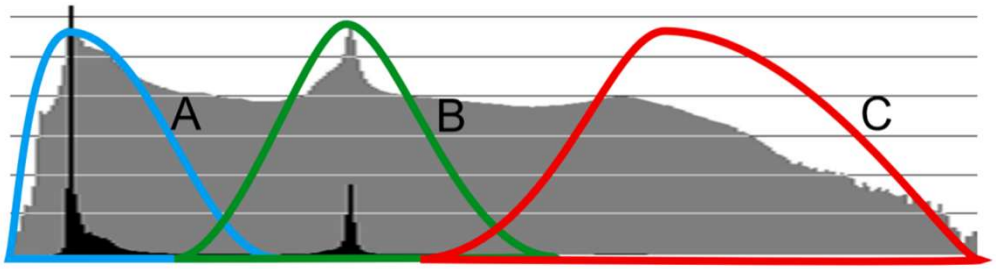
Figure 10.2. Relationships between f, f', f'' in an ideal boundary.

2D Transfer Functions

1D transfer function

- Horizontal axis: scalar value
- Vertical axis: number of voxels

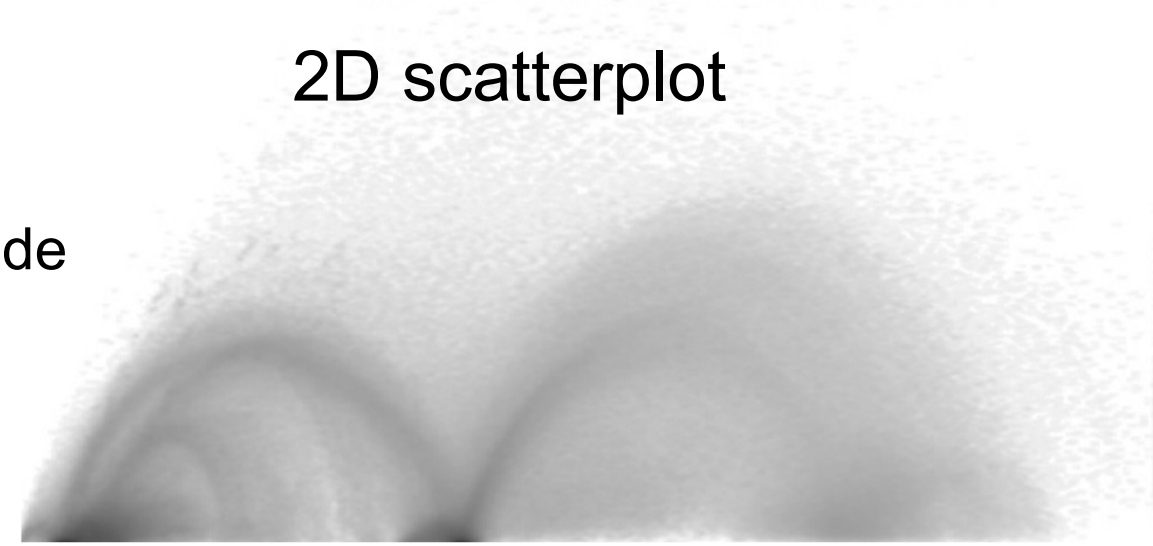
1D histogram



2D transfer function

- Horizontal axis: scalar value
- Vertical axis: gradient magnitude
- Brightness: number of voxels (here: darker means more)

2D scatterplot



[Kniss et al. 2002]

2D Transfer Functions

1D transfer function

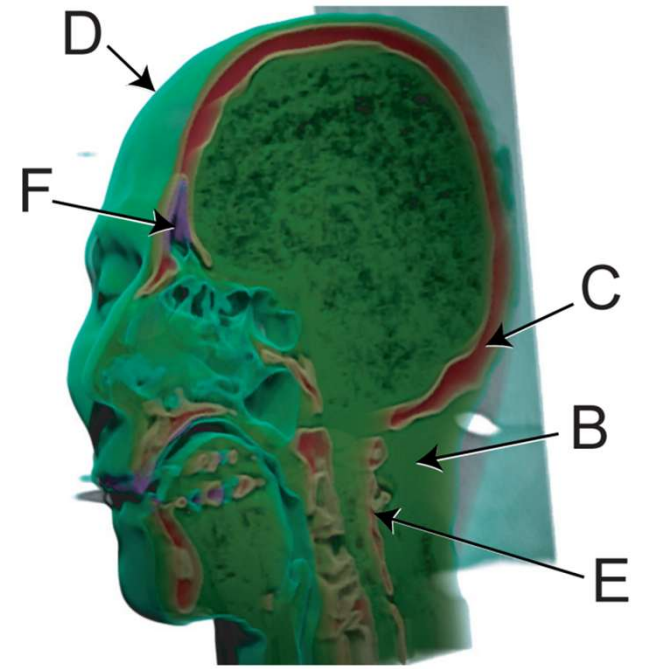
Horizontal axis: scalar value

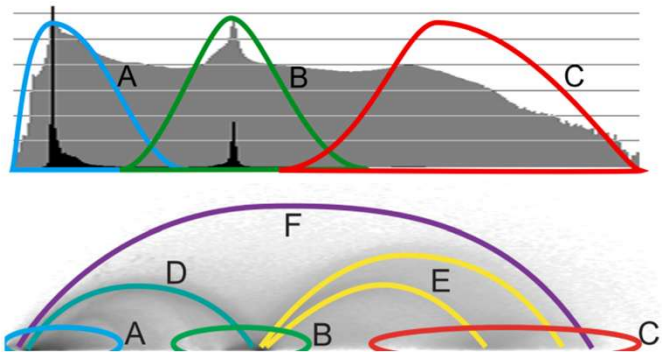
Vertical axis: number of voxels

2D transfer function

Horizontal axis: scalar value

Vertical axis: gradient magnitude

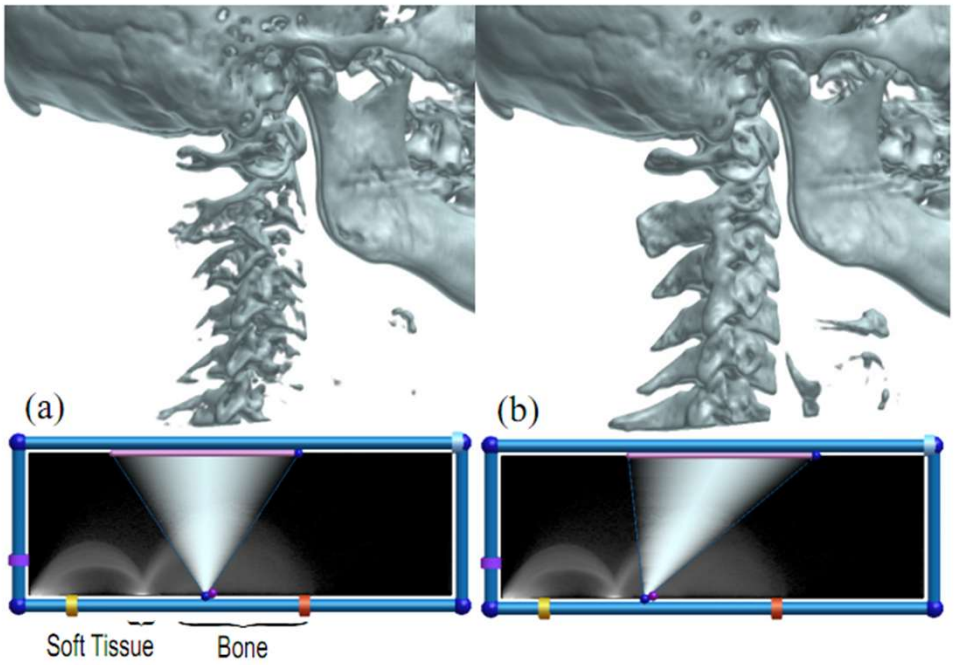


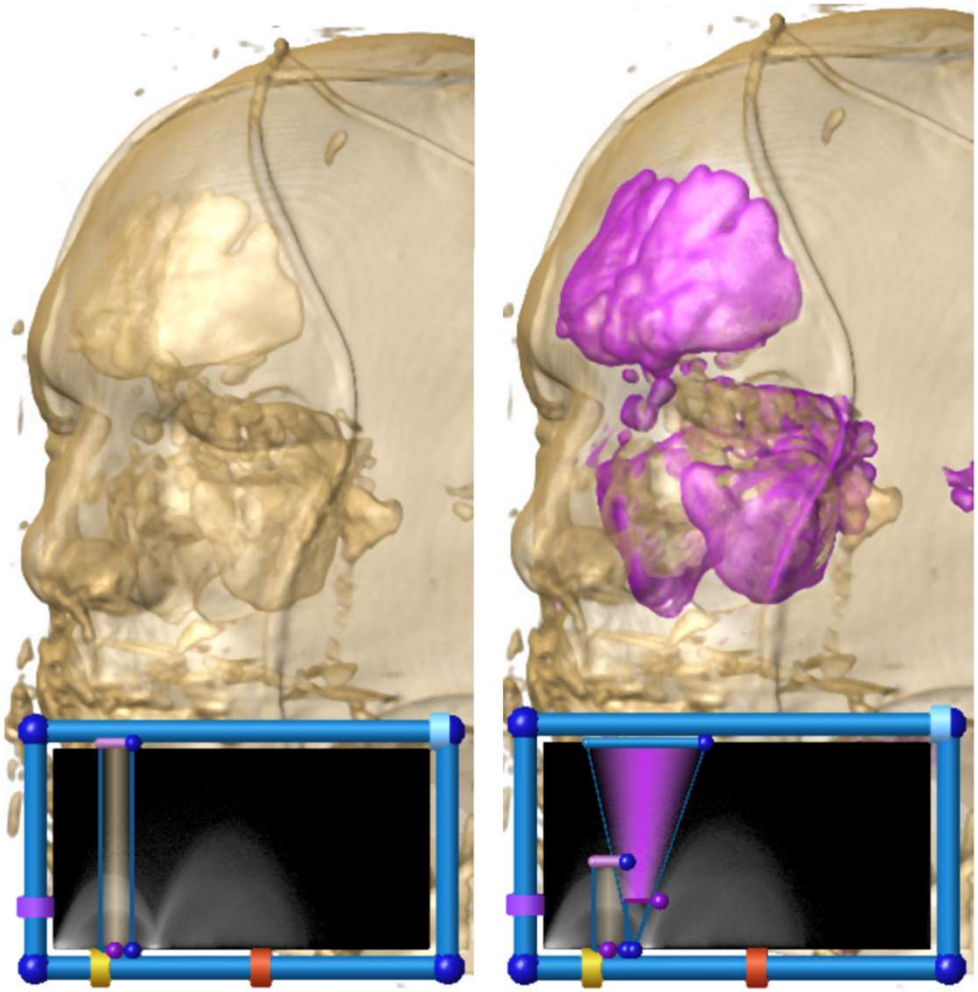


[Kniss et al. 2002]

2D Transfer Functions

Comparisons





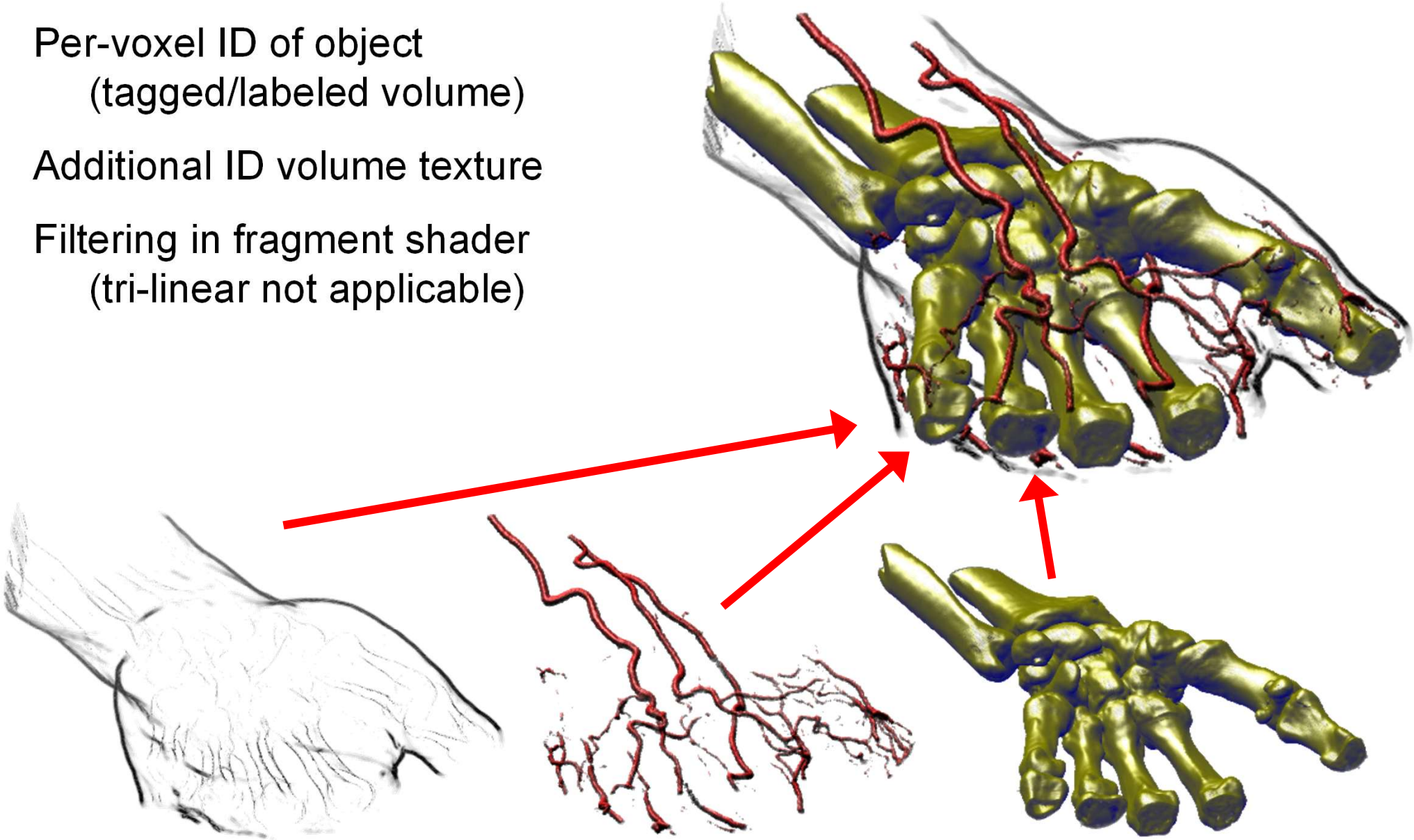
[Kniss et al. 2002]

Rendering Segmented Volumes (1)

Per-voxel ID of object
(tagged/labeled volume)

Additional ID volume texture

Filtering in fragment shader
(tri-linear not applicable)



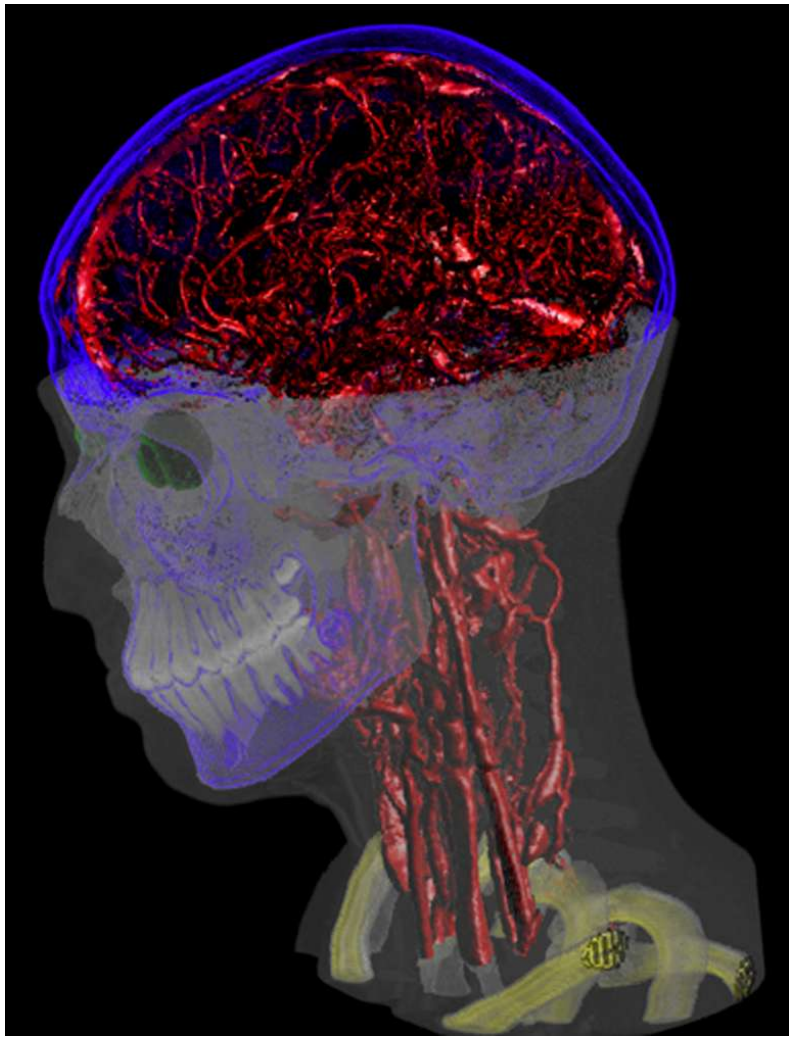
Rendering Segmented Volumes (2)

Focus and context

Per-object transfer function

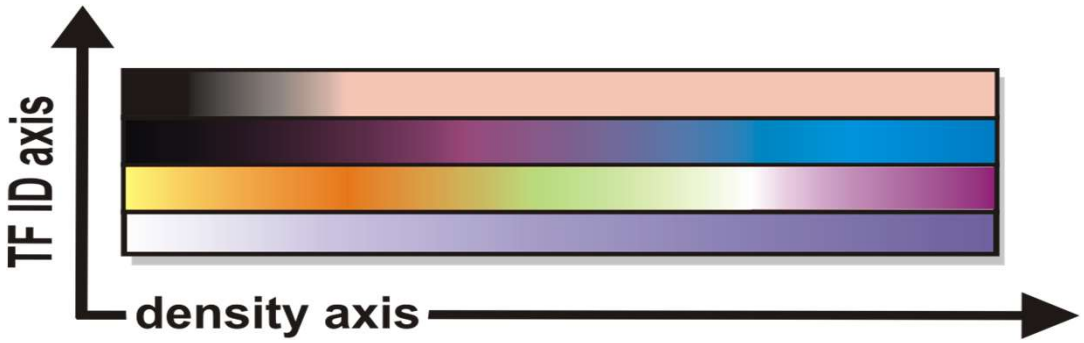
Per-object rendering mode

Per-object compositing



Per-Object Transfer Functions

Put all transfer functions in one global TF texture



index with object ID
as additional axis

```
tf_coords.x = tex3D( density_tex, sample_pos );
tf_coords.y = tex3D( objectid_tex, sample_pos );
classified_sample.rgba = tex2D( tf_tex, tf_coords );
```

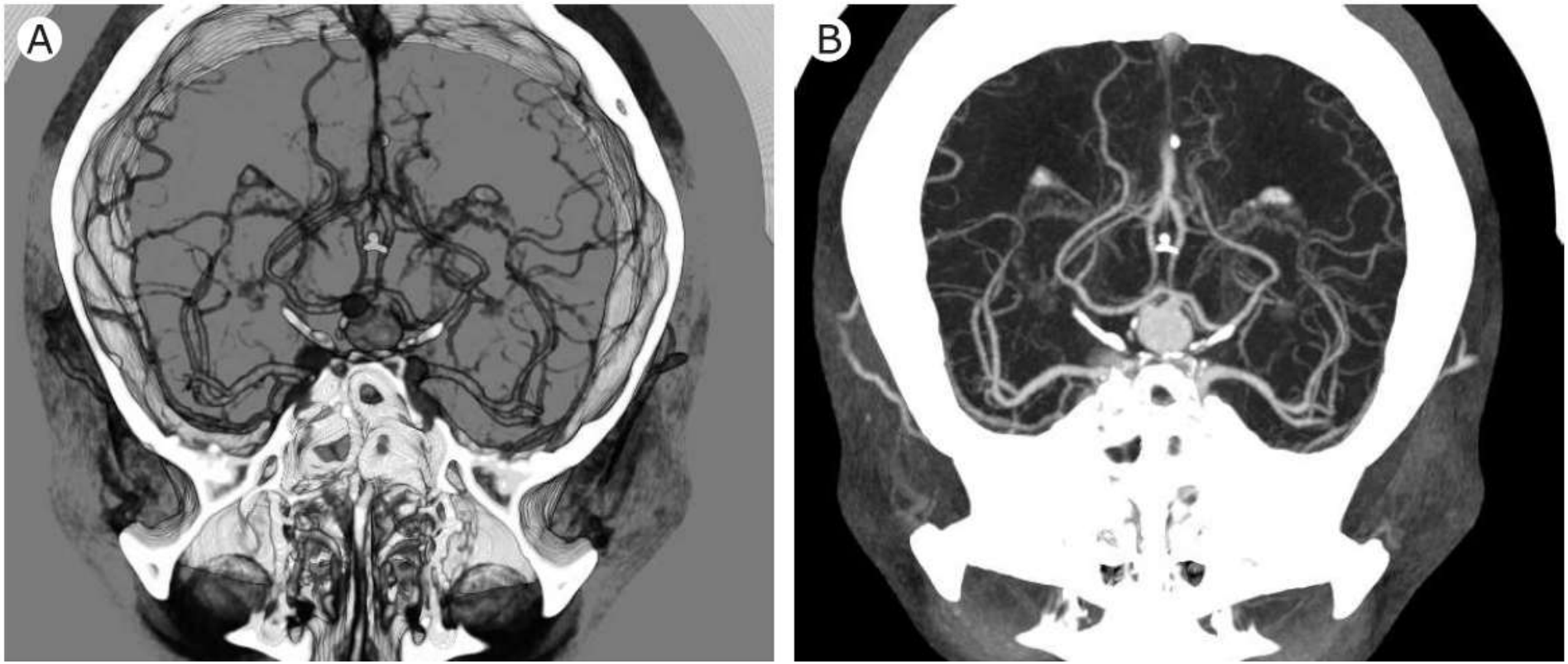
1D transfer functions → 2D texture

2D transfer functions → 3D texture

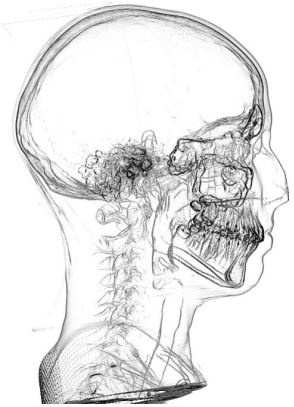
Maximum Intensity Projection

Alternative compositing mode (no alpha blending)

Keeps structure of maximum intensity visible



Volumetric Boundary Contours (1)

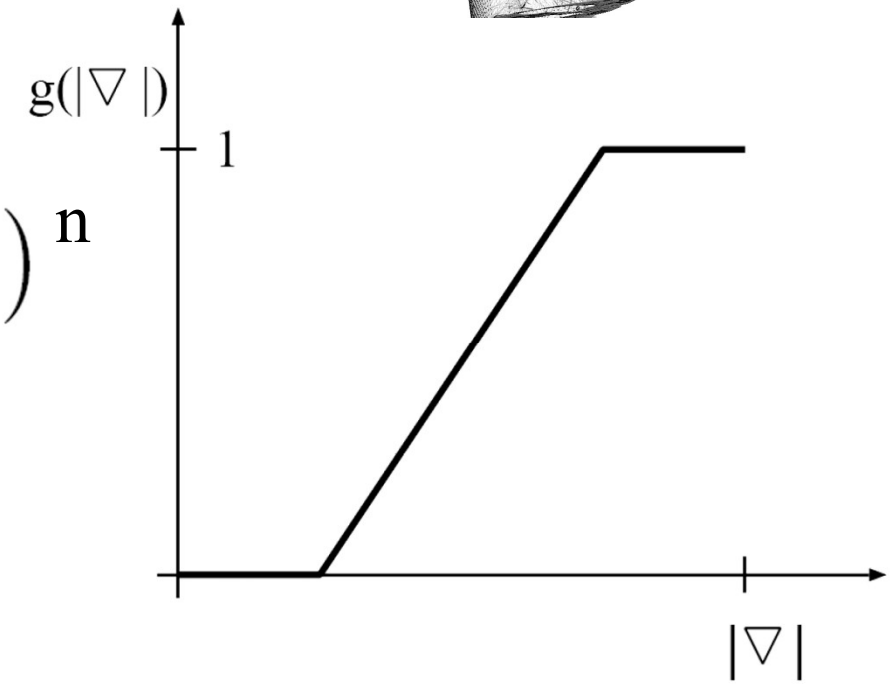


Based on view direction and gradient magnitude

Global boundary detection
instead of isosurface

Gradient magnitude window g(.)

$$\mathbf{I} = g\left(|\nabla f|\right) \cdot \left(1 - |\mathbf{v} \cdot \mathbf{n}|\right)^{\mathrm{n}}$$



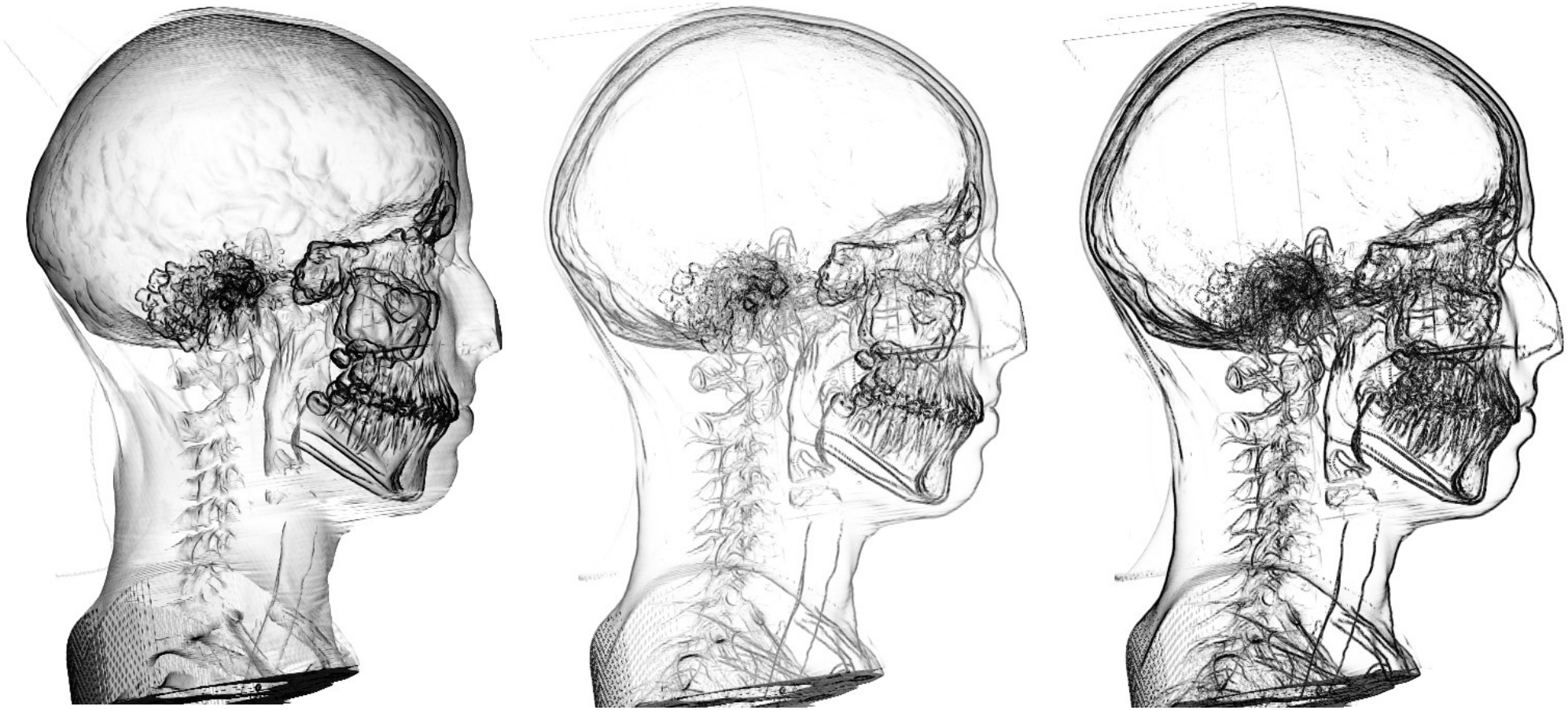
Exponent determines silhouette range

Does not work for distance fields!

Volumetric Boundary Contours (2)

Gradient magnitude window is main parameter

Exponent between 4 and 16 is good choice



Thank you.

Thanks for material

- Helwig Hauser
- Eduard Gröller
- Daniel Weiskopf
- Torsten Möller
- Ronny Peikert
- Philipp Muigg
- Christof Rezk-Salama