CS 247 – Scientific Visualization
Lecture 20: Volume Rendering, Pt. 7 [preview]

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Reading Assignment #11 (until Apr 11)

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)

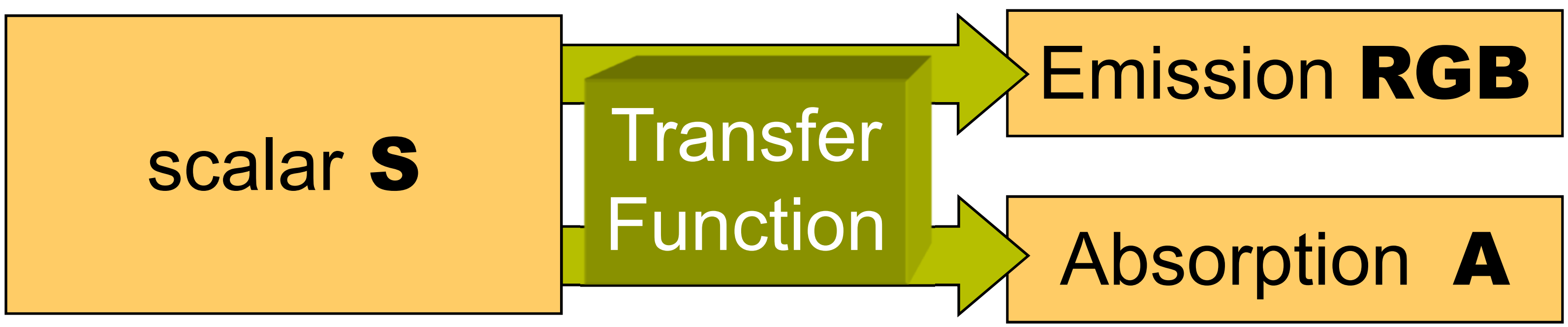
More on Transfer Functions

Classification – Transfer Functions

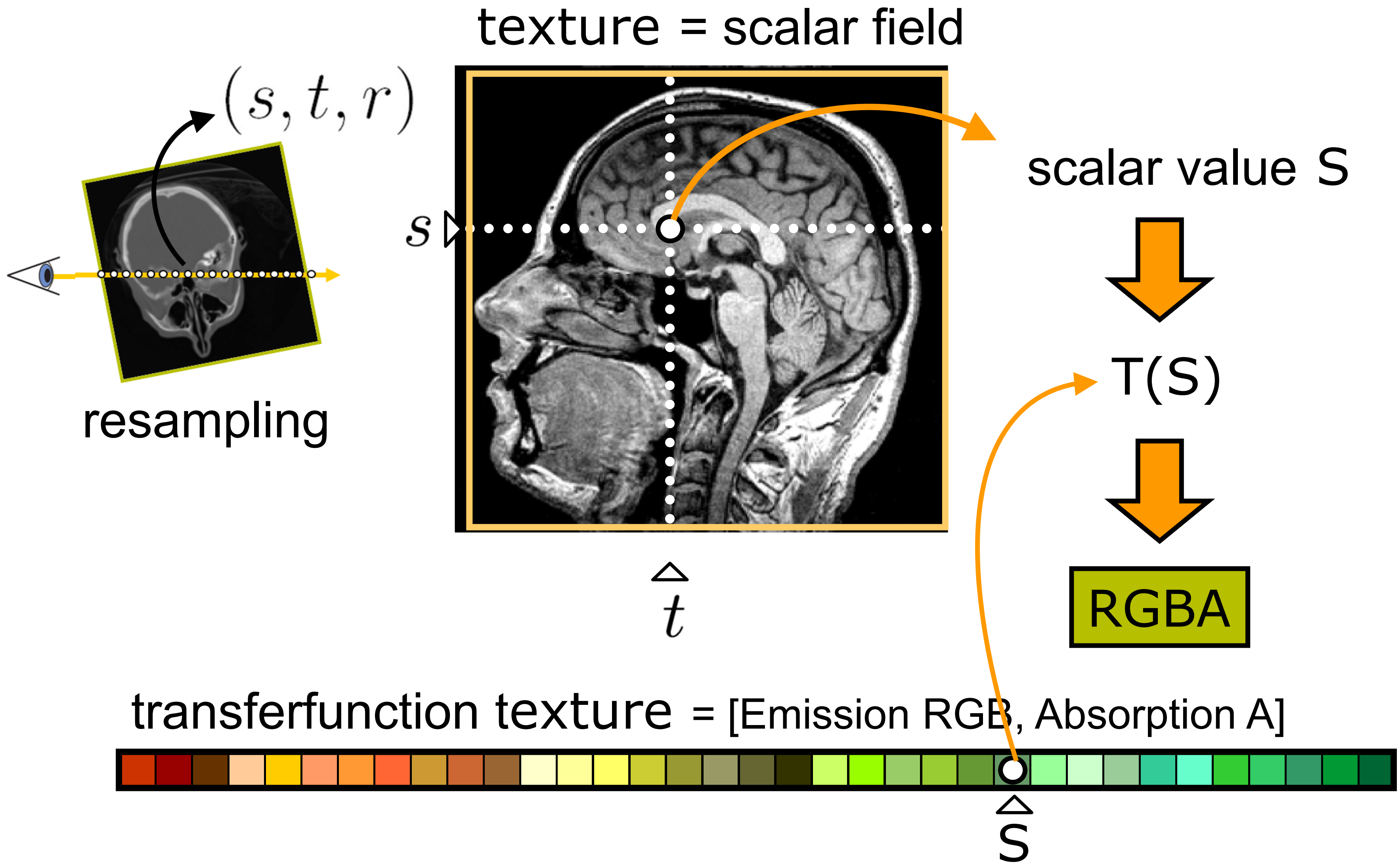
During Classification the user defines the ***"look"*** of the data.

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

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

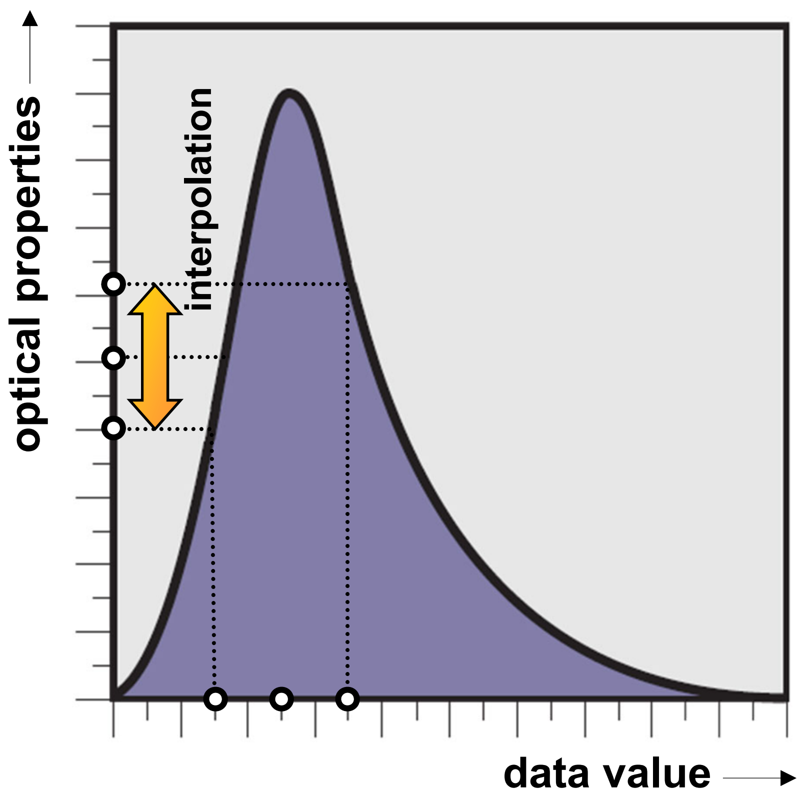


1D Transfer Functions

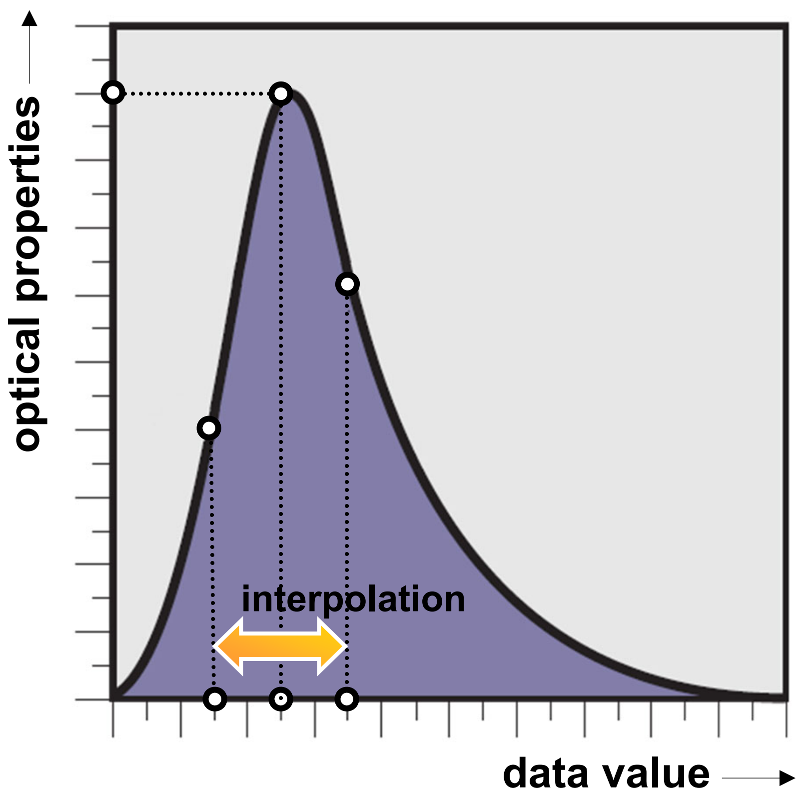


Pre- vs Post-Interpolative Classification

PRE-INTERPOLATIVE

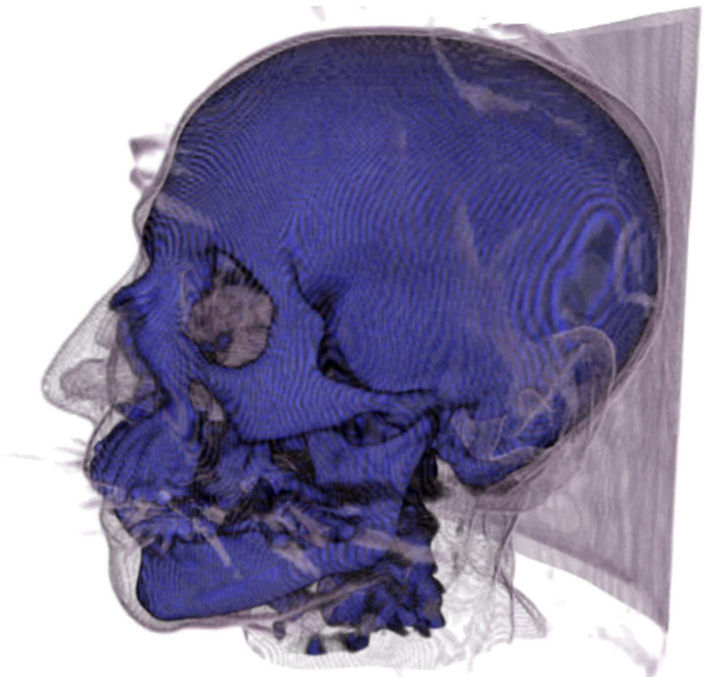


POST-INTERPOLATIVE

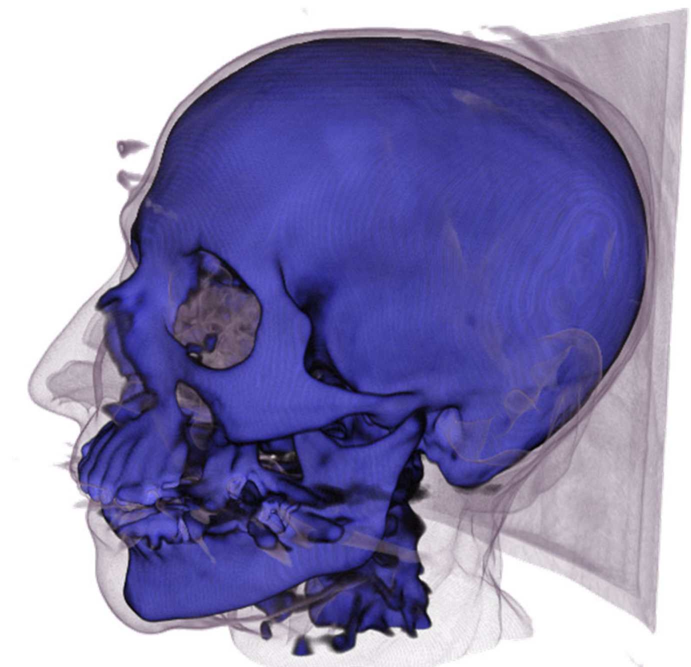


Quality: Pre- vs. Post-Classification

Comparison of image quality



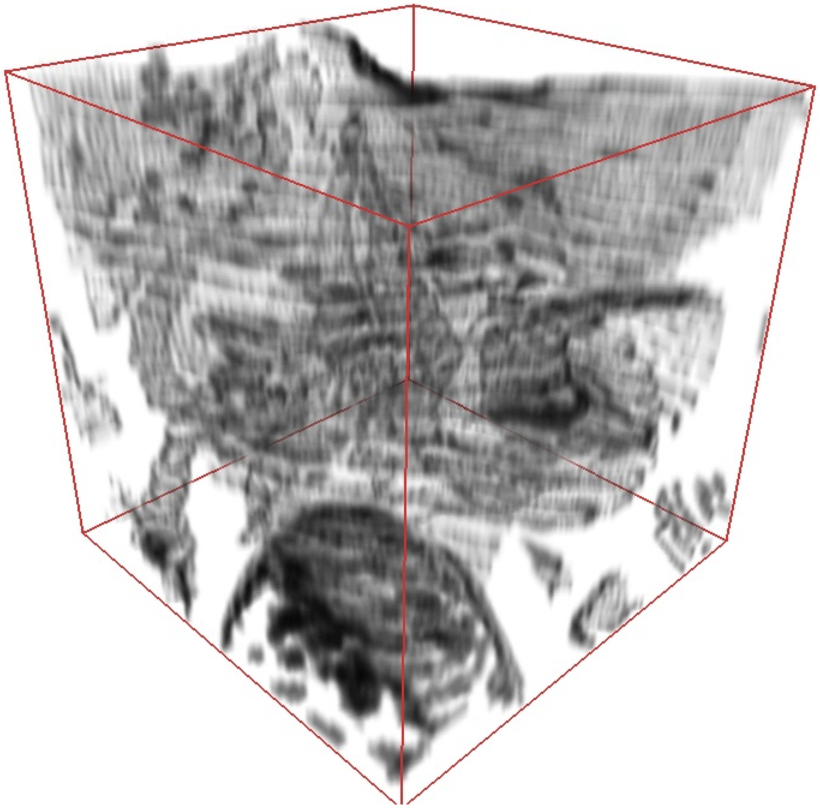
Pre-Classification



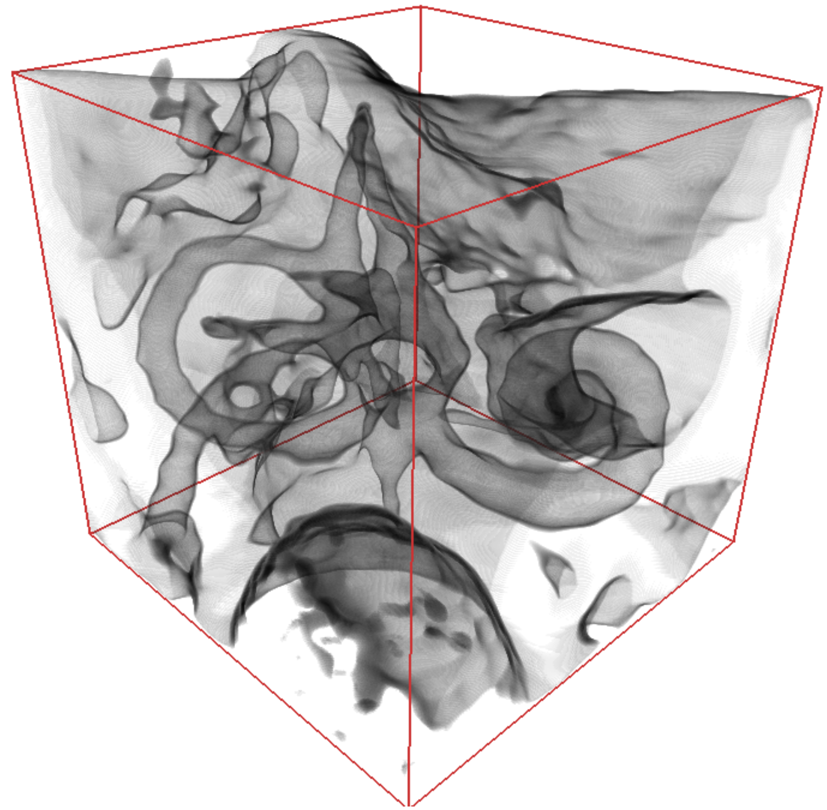
Post-Classification

same TF, same resolution, same sampling rate

Quality: Pre- vs. Post-Classification

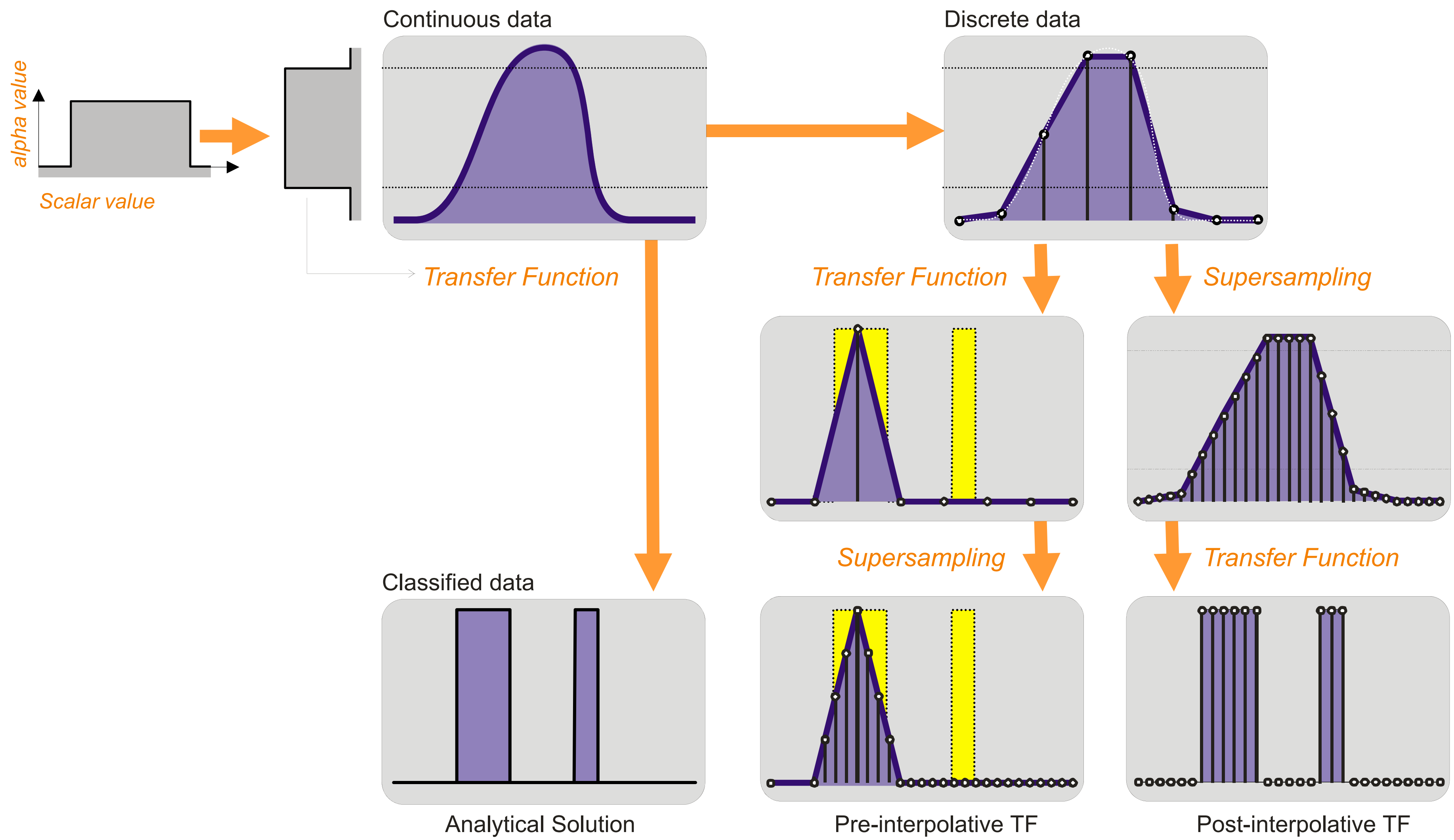


Pre-Classification

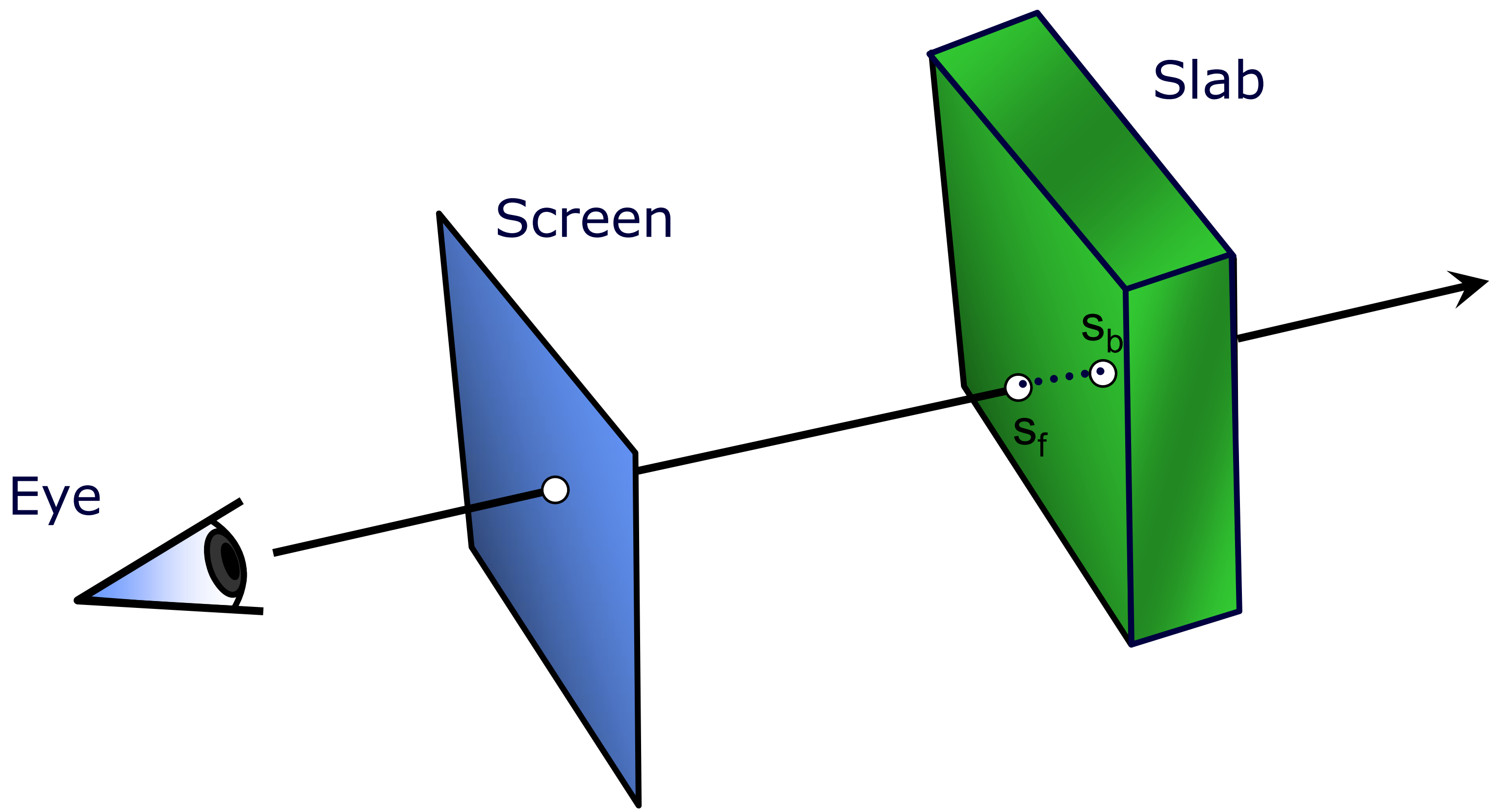


Post-Classification

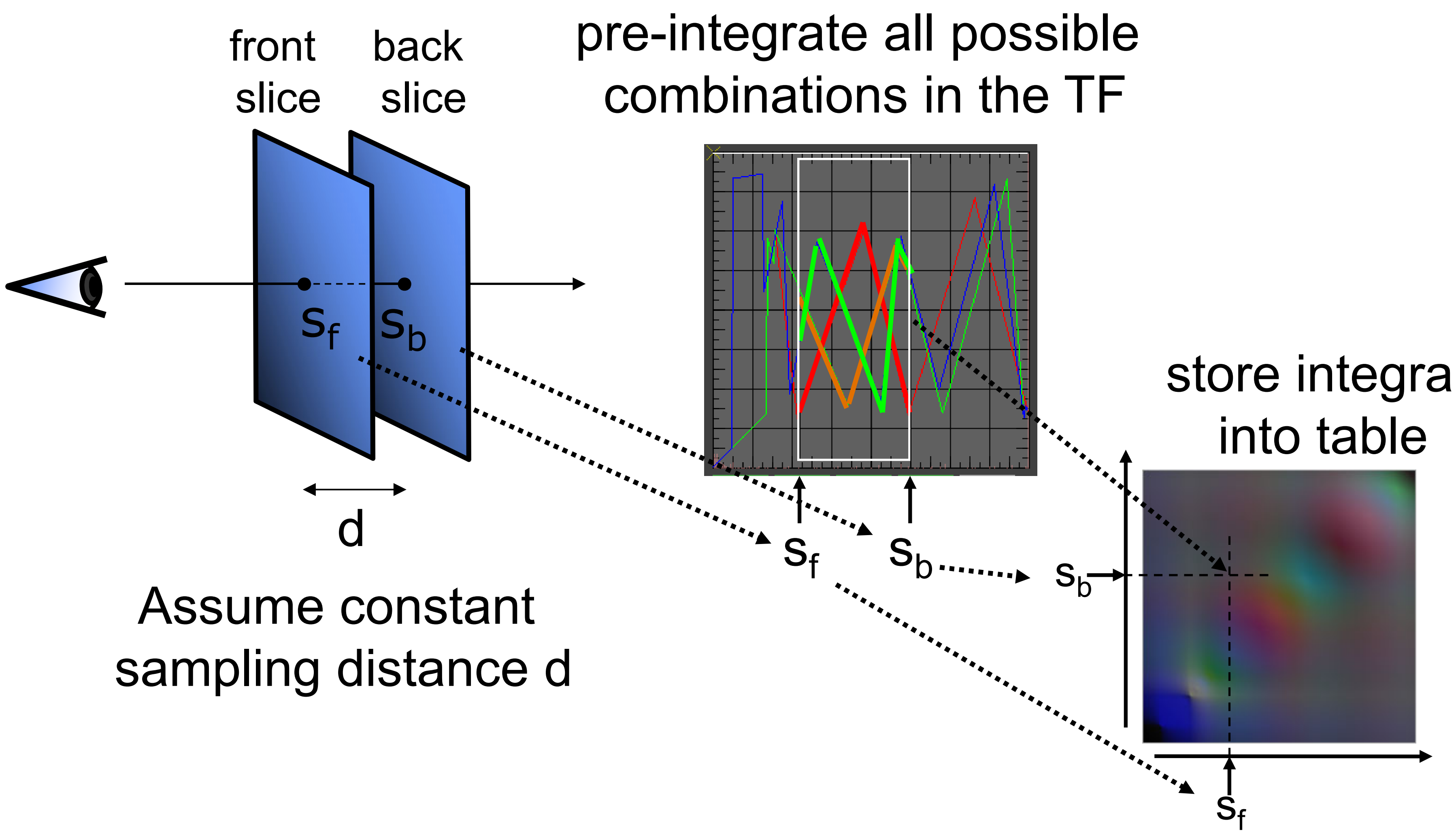
Pre- vs Post-Classification



Pre-Integrated Classification



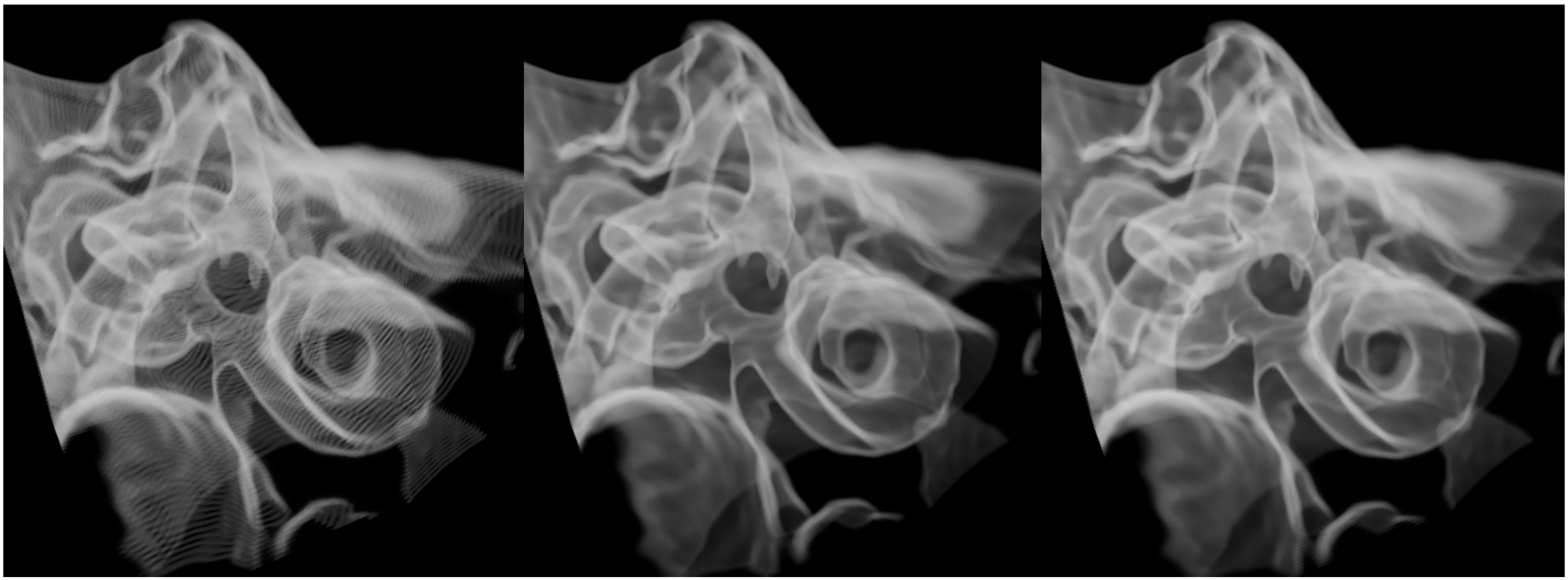
Pre-Integrated Classification



Assume constant sampling distance d

Pre-Integrated Classification

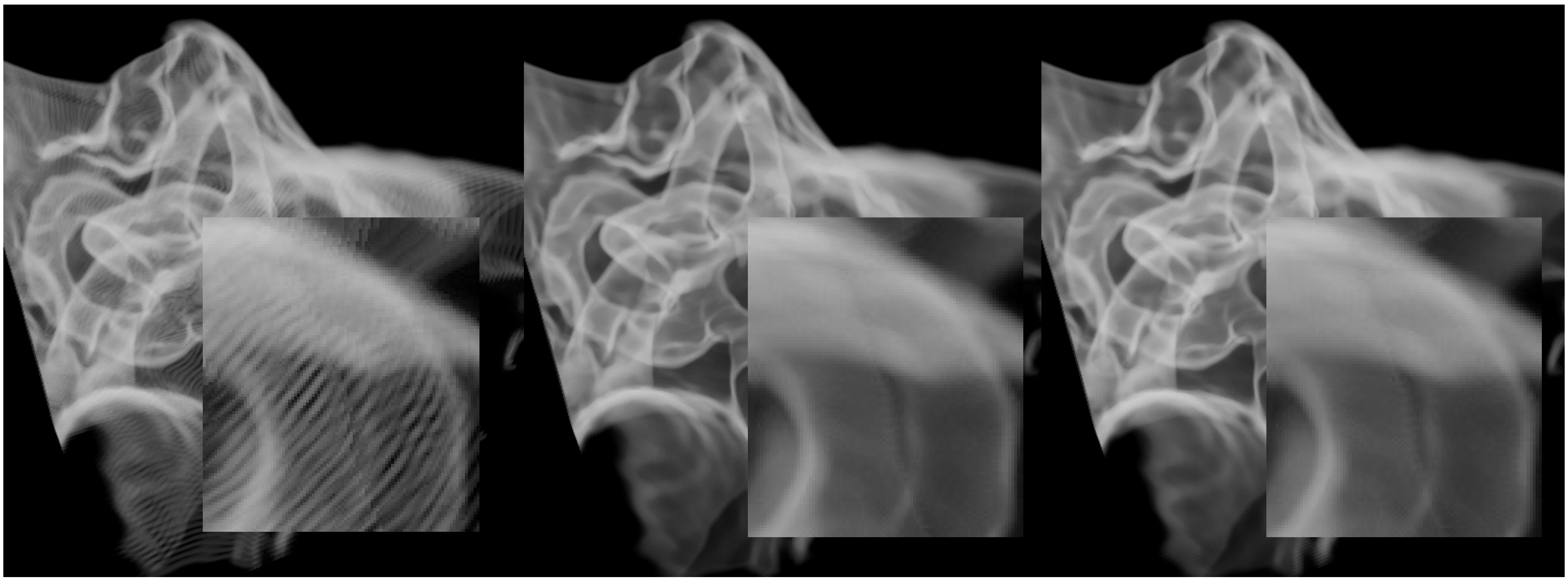
Quality comparison



128 Slices | 284 Slices | 128 Slabs

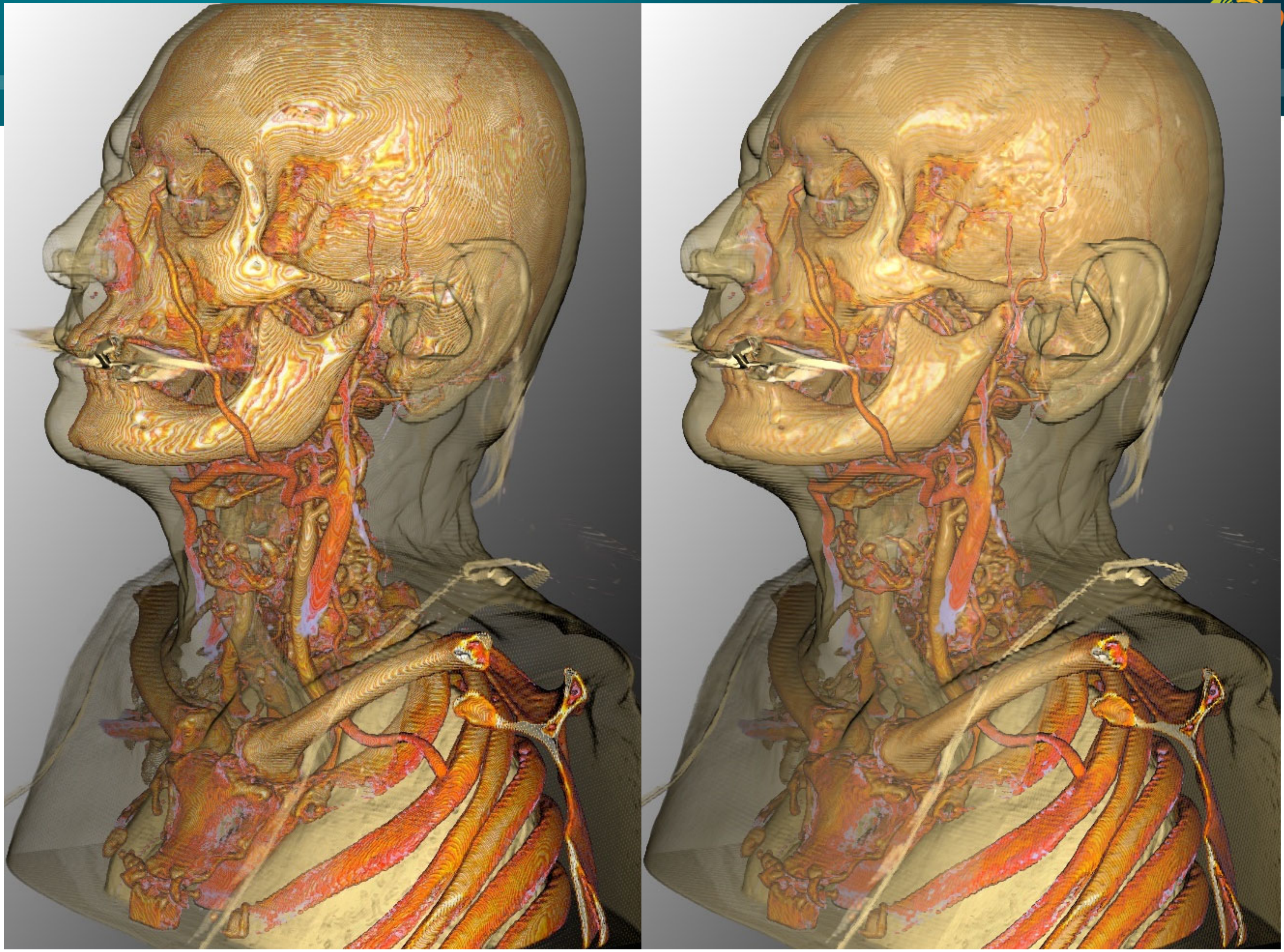
Pre-Integrated Classification

Quality comparison

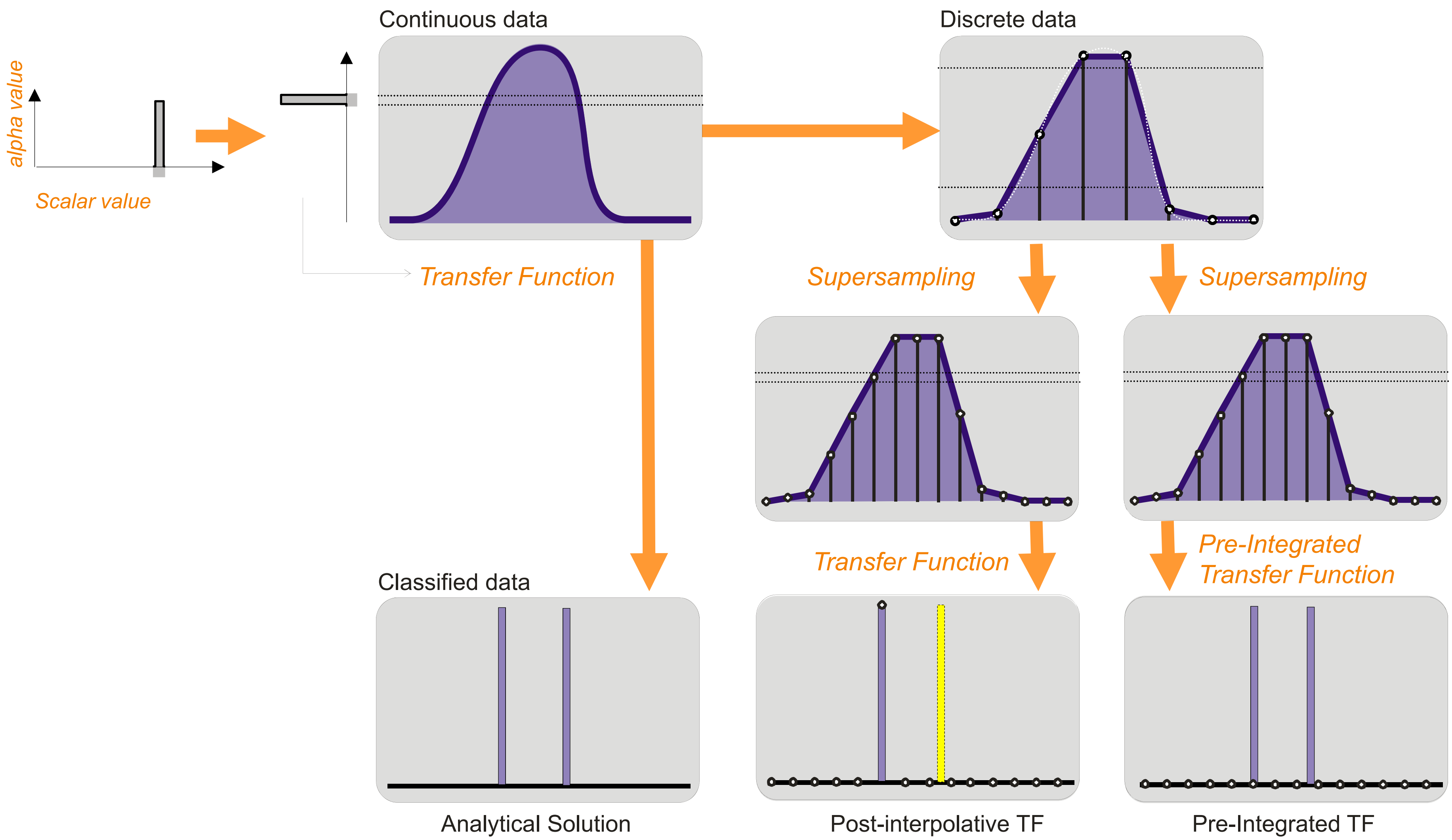


128 Slices　　284 Slices　　128 Slabs

Pre-Integrated Classification



Post- vs. Pre-Integrated Classification



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

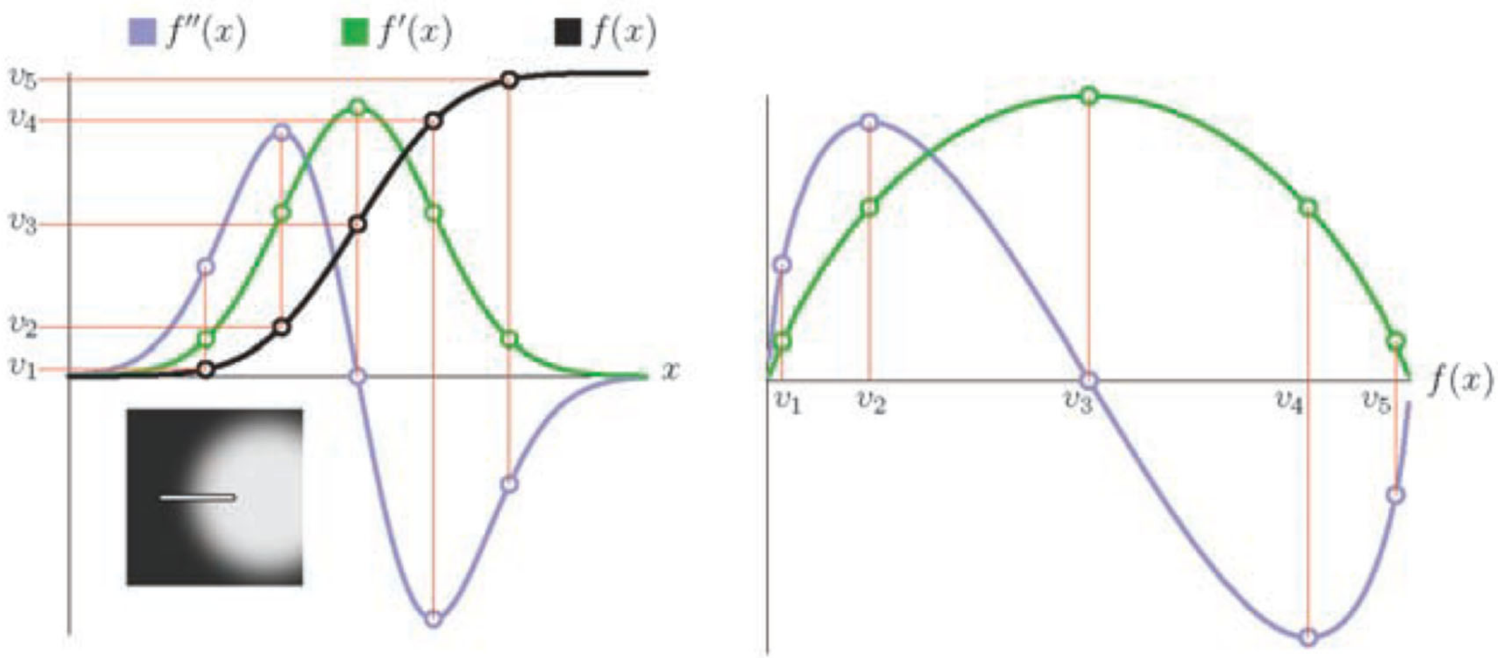


Figure 10.2. Relationships between f, f', f'' in an ideal boundary.

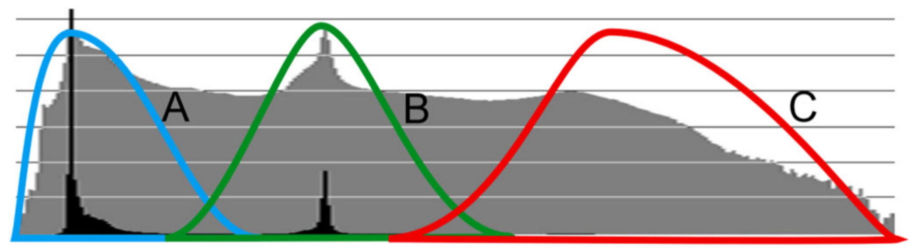
2D Transfer Functions

1D transfer function

Horizontal axis: scalar value

Vertical axis: number of voxels

1D histogram



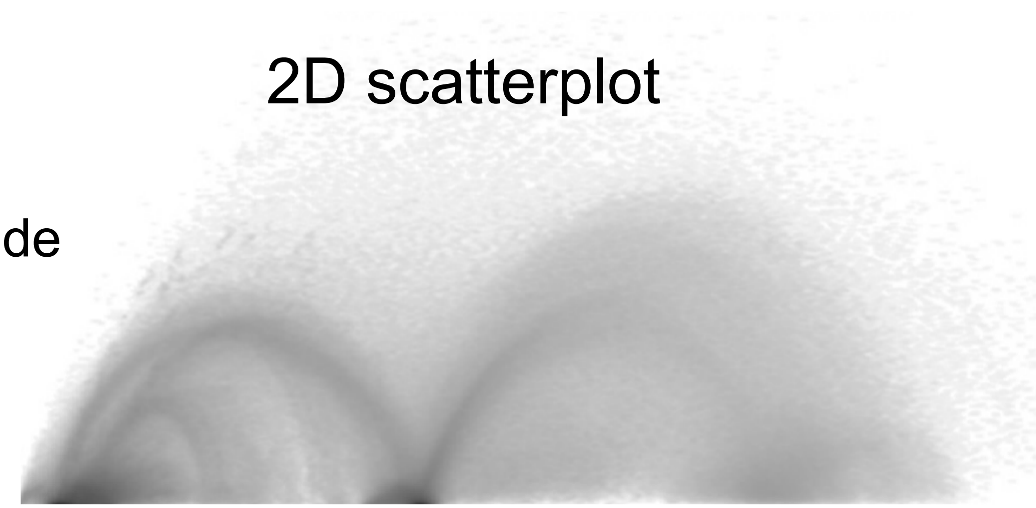
2D transfer function

Horizontal axis: scalar value

Vertical axis: gradient magnitude

Brightness: number of voxels
(here: darker means more)

2D scatterplot



[Kniss et al. 2002]

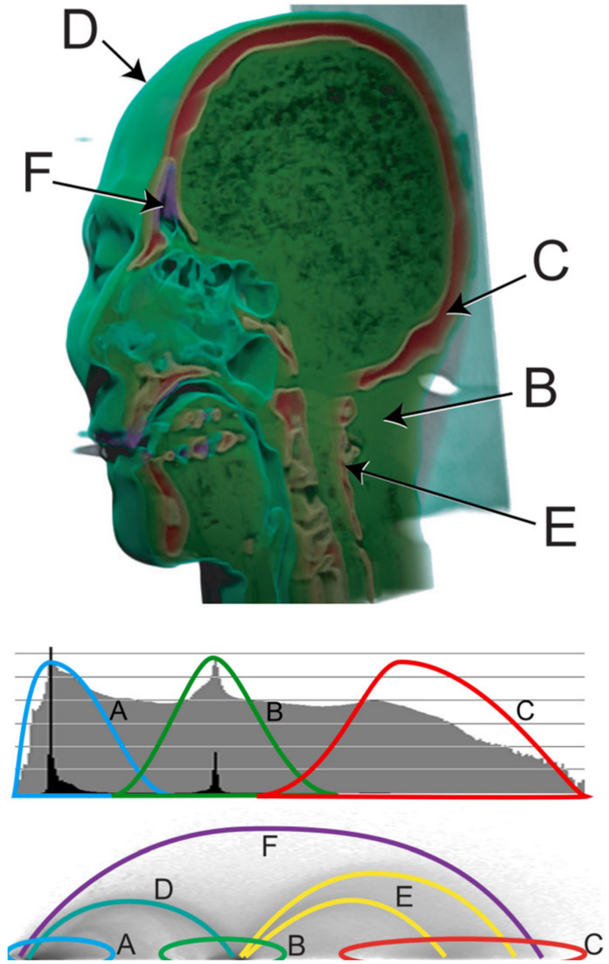
2D Transfer Functions

1D transfer function

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

2D transfer function

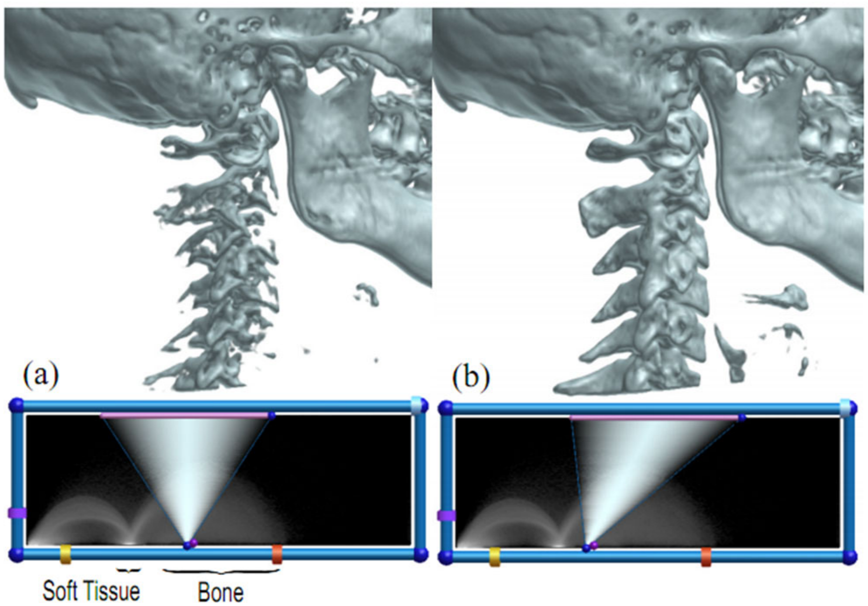
- Horizontal axis: scalar value
- Vertical axis: gradient magnitude

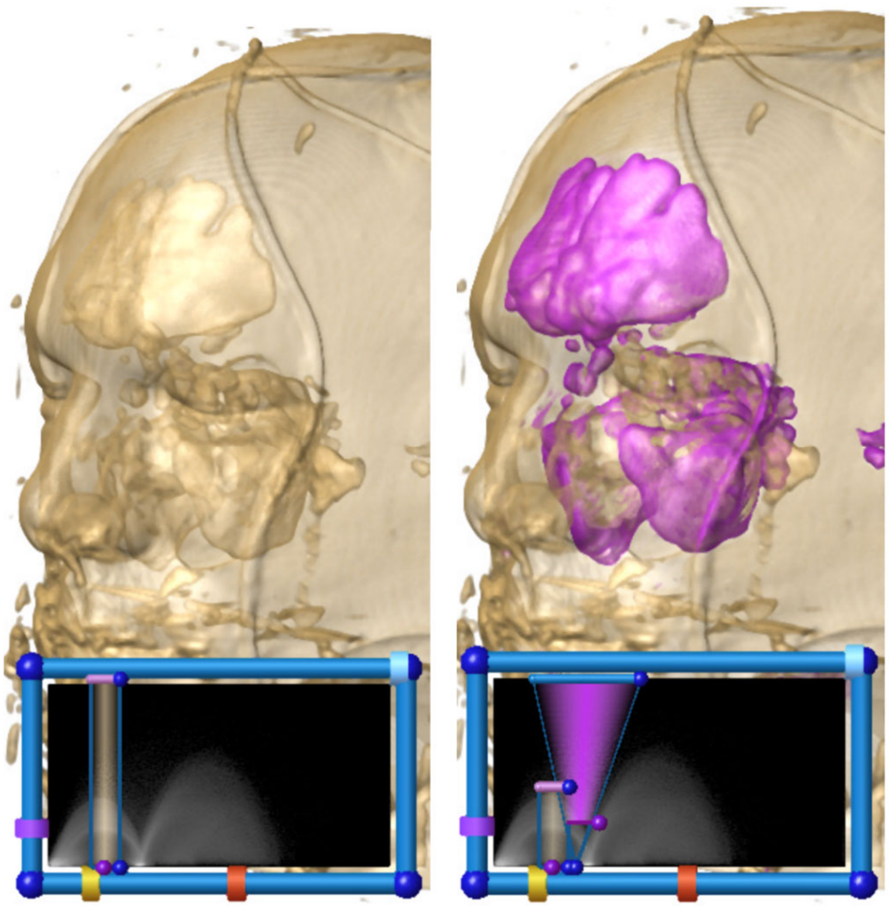


[Kniss et al. 2002]

2D Transfer Functions

Comparisons





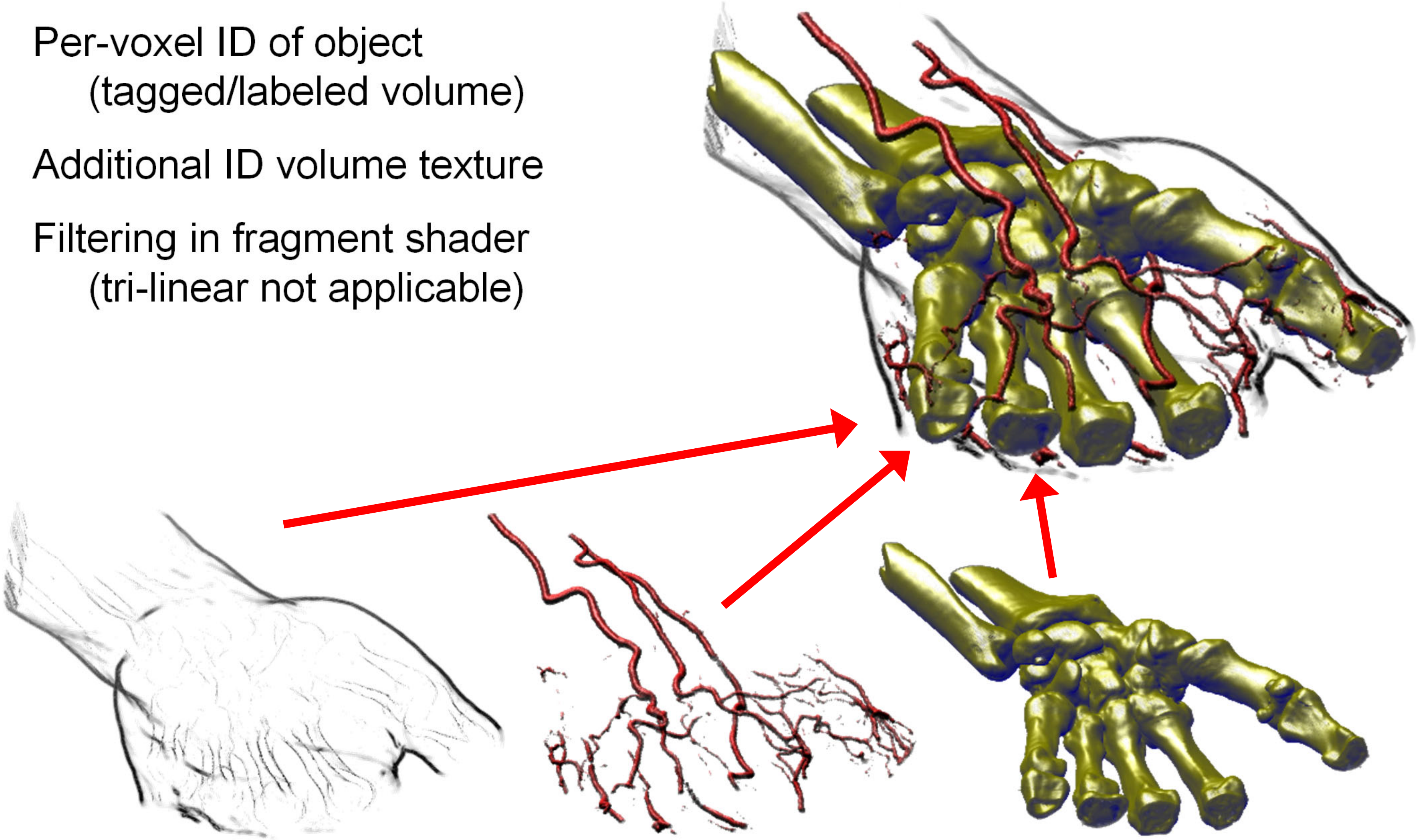
[Kniss et al. 2002]

Rendering Segmented Volumes (1)

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

Additional ID volume texture

Filtering in fragment shader
  (tri-linear not applicable)



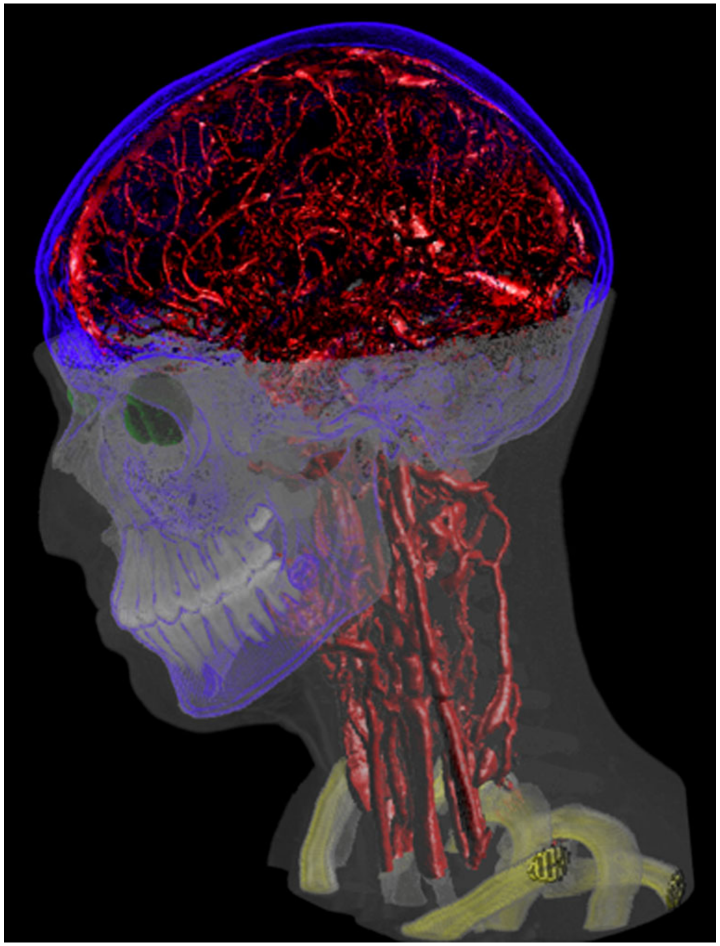
Rendering Segmented Volumes (2)

Focus and context

Per-object transfer function

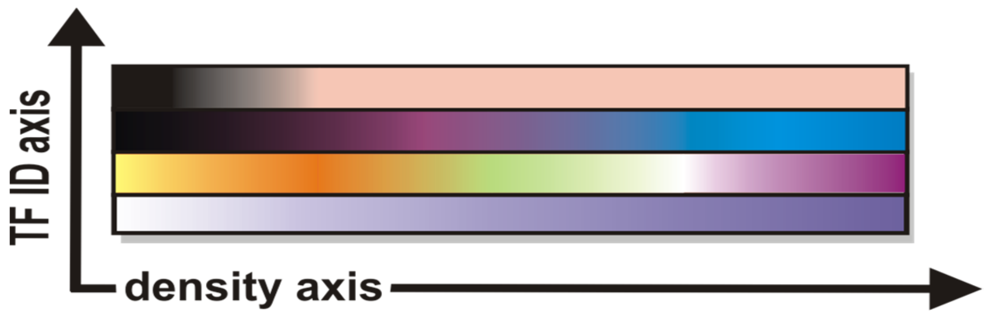
Per-object rendering mode

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 );
```

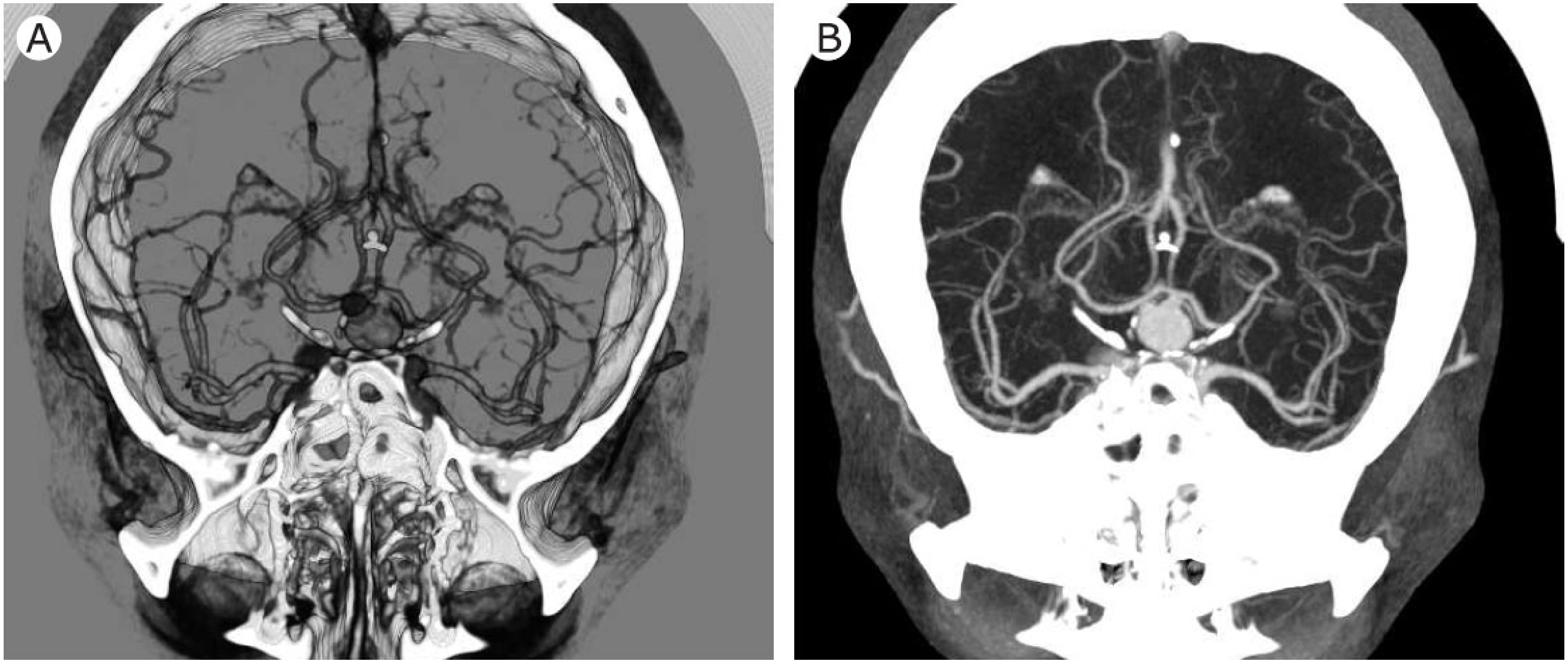
1D transfer functions → 2D texture

2D transfer functions → 3D texture

Maximum Intensity Projection

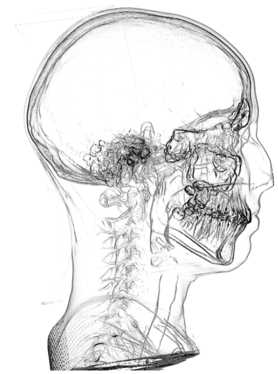
Alternative compositing mode (no alpha blending)

Keeps structure of maximum intensity visible



Volumetric Boundary Contours (1)

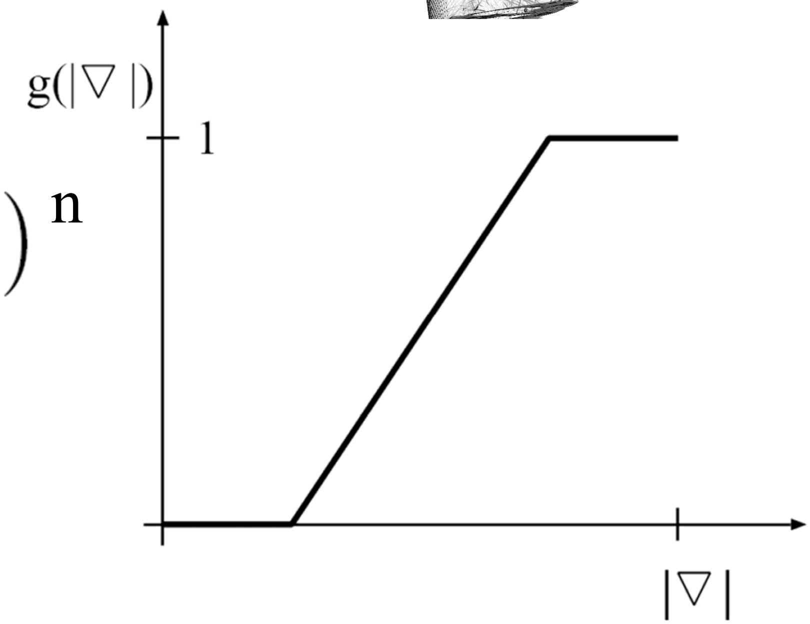
Based on view direction and gradient magnitude



Global boundary detection
instead of isosurface

Gradient magnitude window g(.)

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



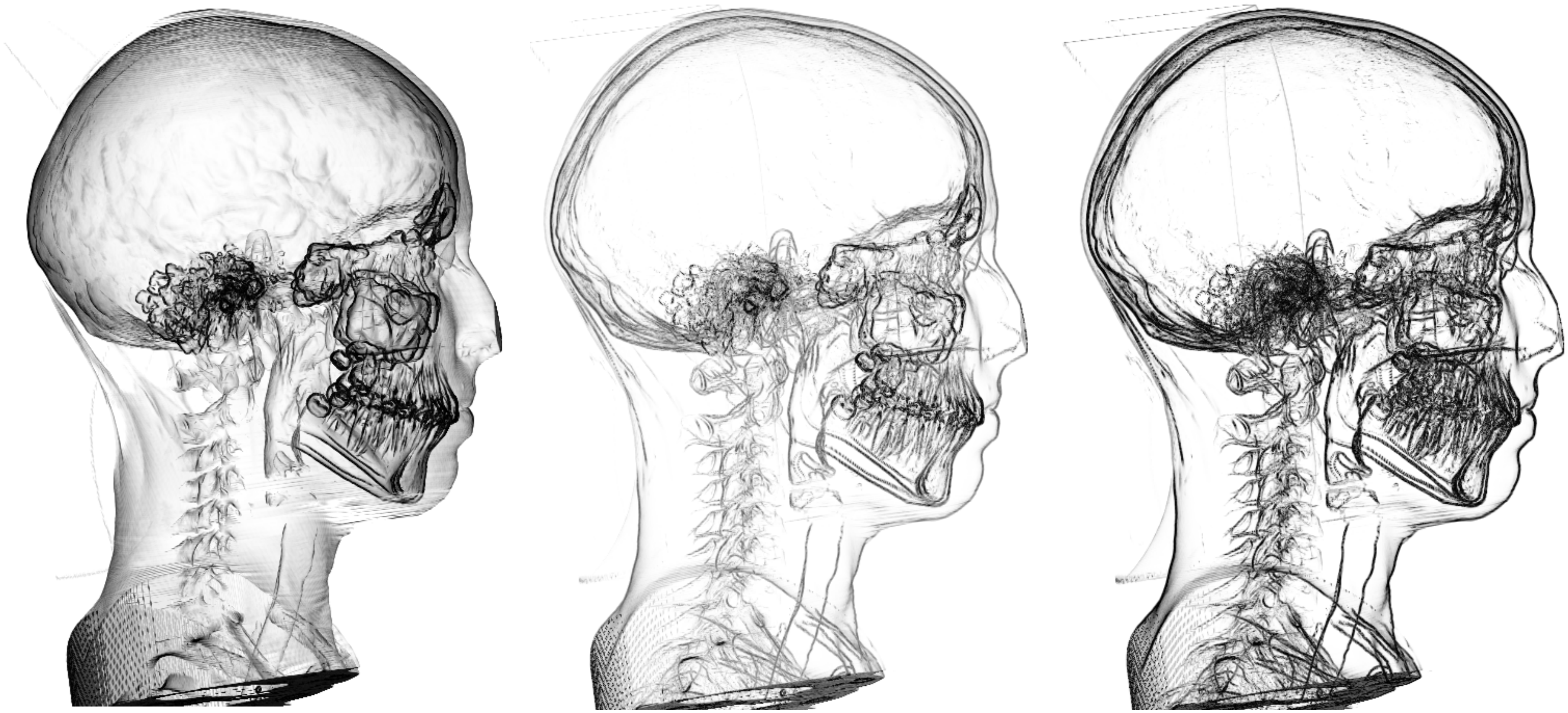
Exponent determines silhouette range

Does not work for distance fields!

Volumetric Boundary Contours (2)

Gradient magnitude window is main parameter

Exponent between 4 and 16 is good choice

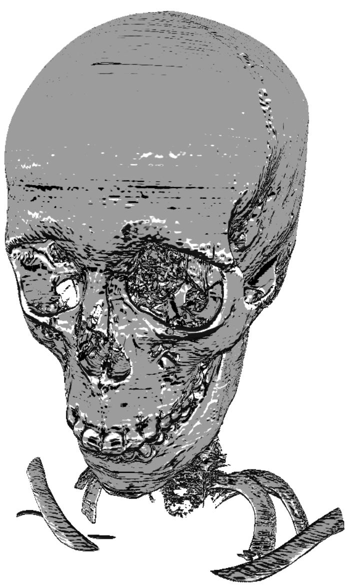


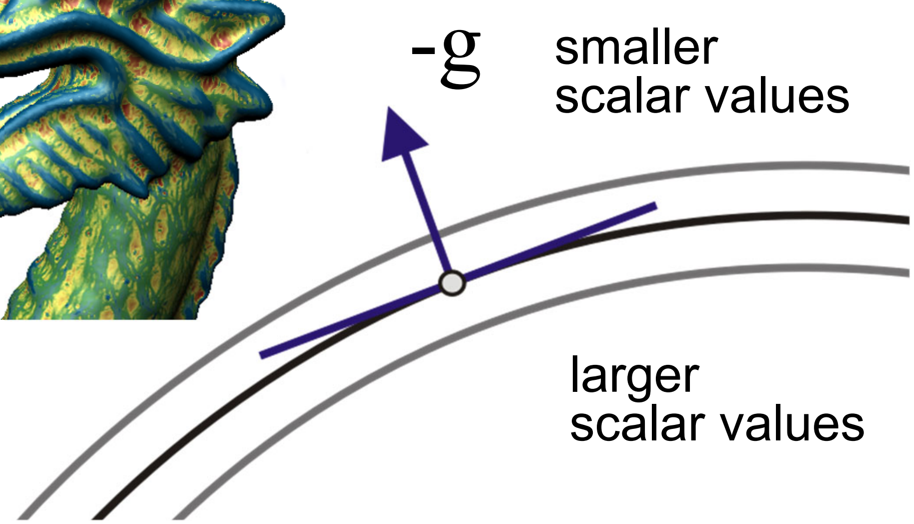
Curvature-Based Transfer Functions

Curvature-Based Isosurface Illustration

Curvature measure color mapping

Curvature directions; ridges and valleys



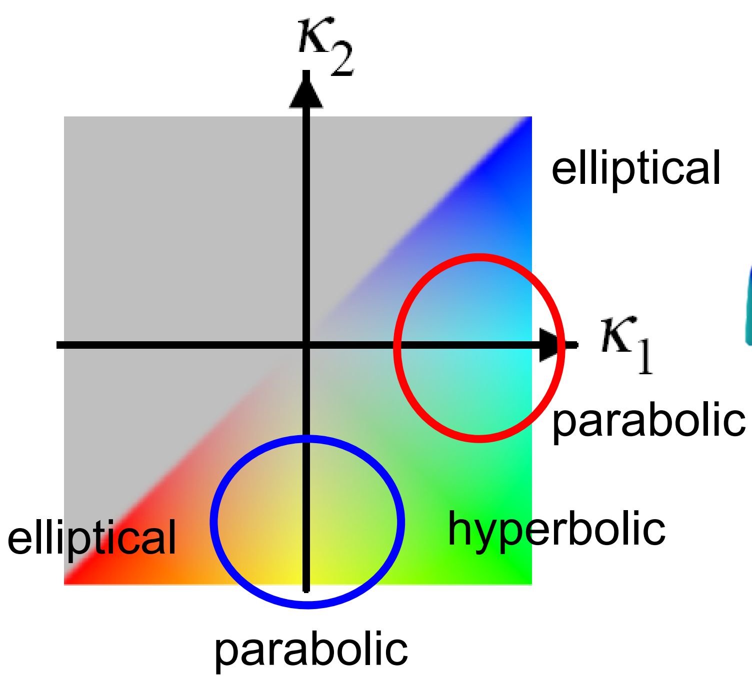


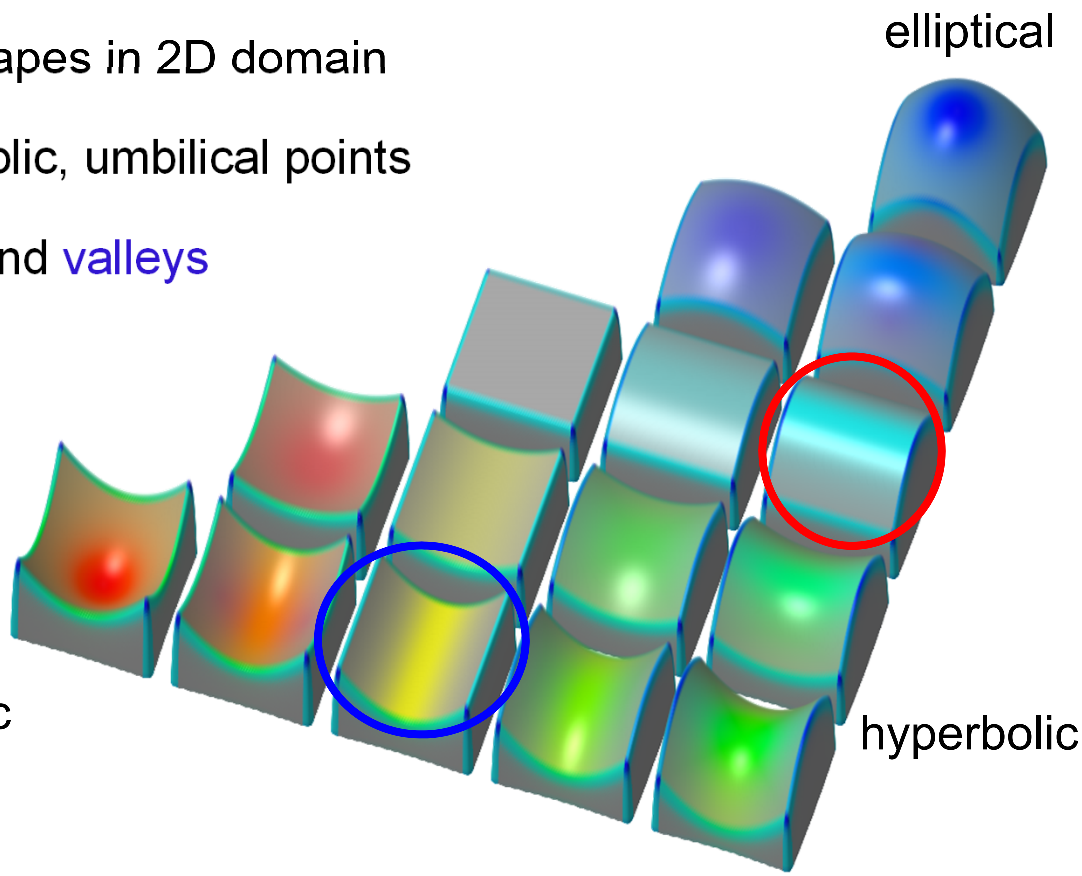
- Implicit surface curvature
- Isosurface through a point

The Principal Curvature Domain

Maximum/minimum principal curvature magnitude

- Identification of different shapes in 2D domain
- Elliptical, parabolic, hyberbolic, umbilical points
- Feature lines: e.g., ridges and valleys

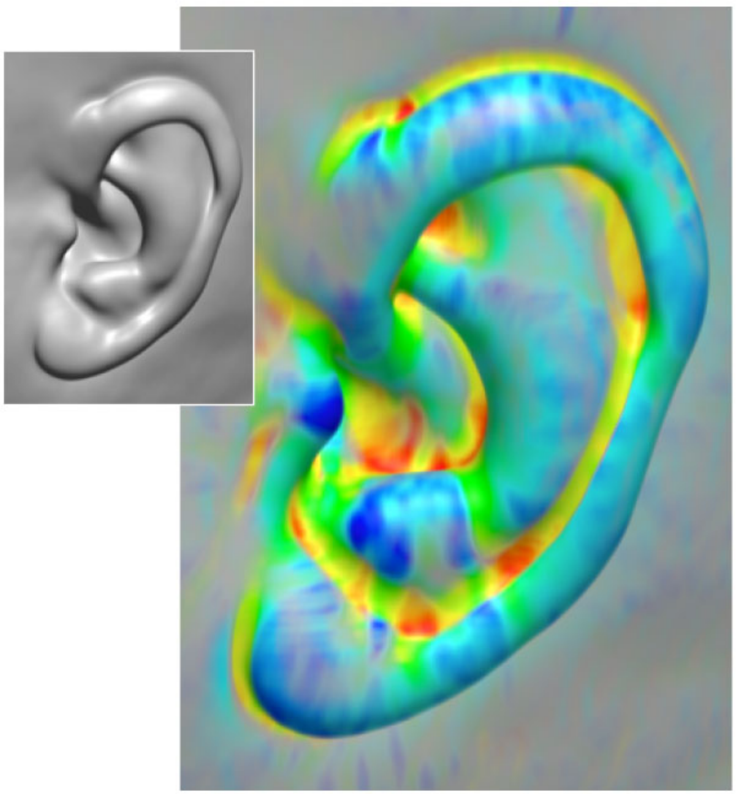


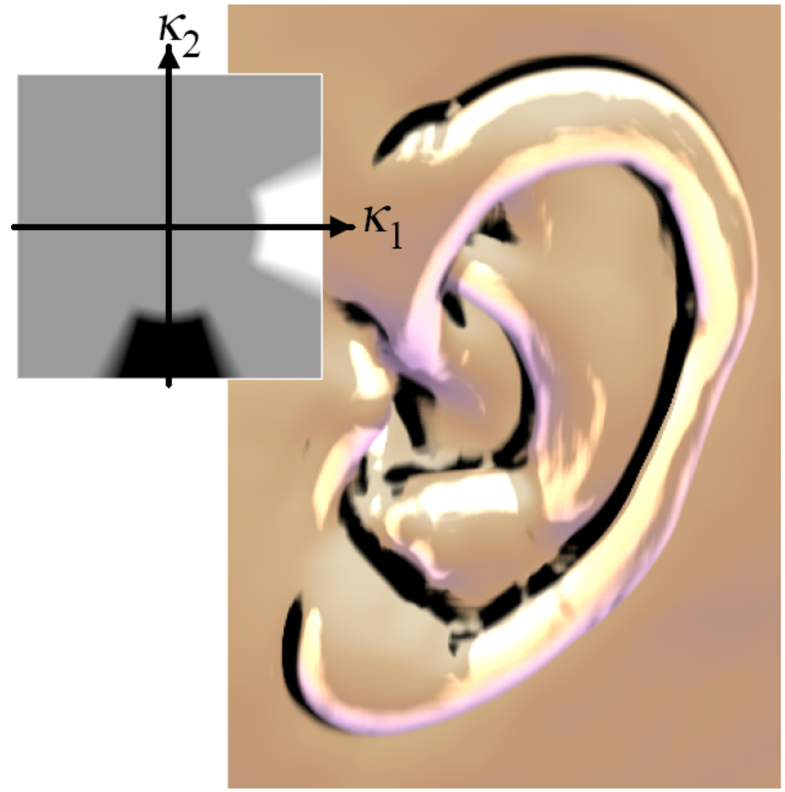


courtesy of Gordon Kindlmann

Curvature Transfer Functions

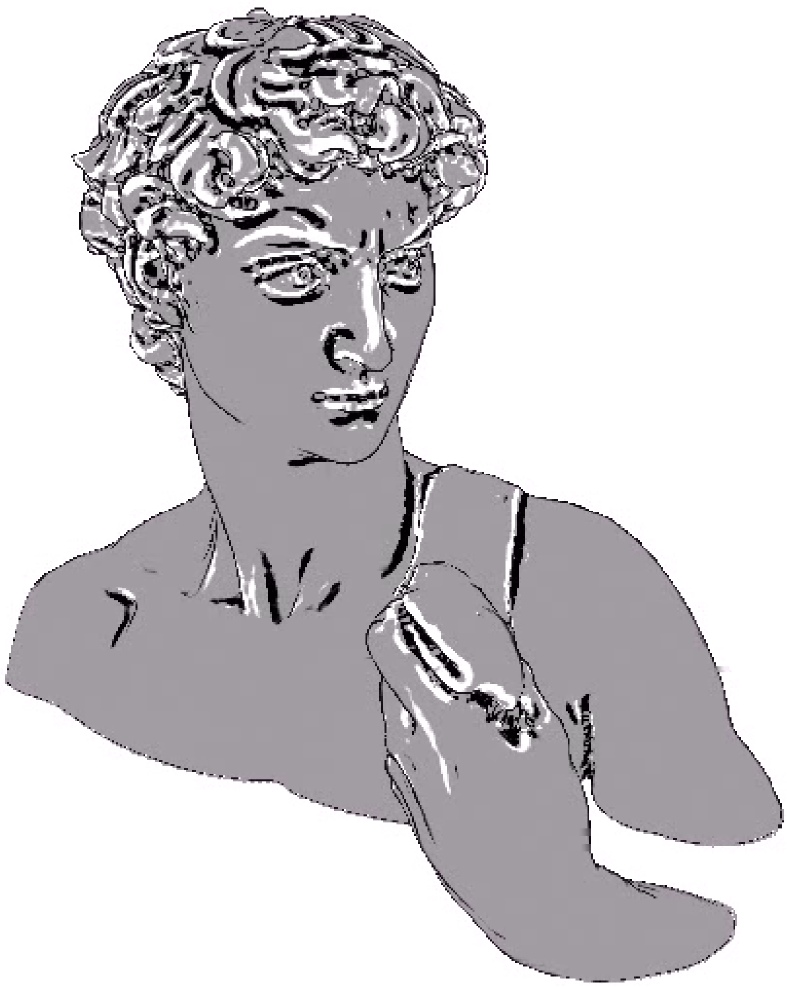
- Color coding of curvature domain
- Paint features: ridge and valley lines





courtesy of Gordon Kindlmann

Example



Thank you.

Thanks for material

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