

CS 247 – Scientific Visualization

Lecture 14: Volume Visualization, Pt. 1

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Reading Assignment #7 (until Mar 19)

Read (required):

- Real-Time Volume Graphics, Chapter 1
(Theoretical Background and Basic Approaches),
from beginning to 1.4.4 (inclusive)

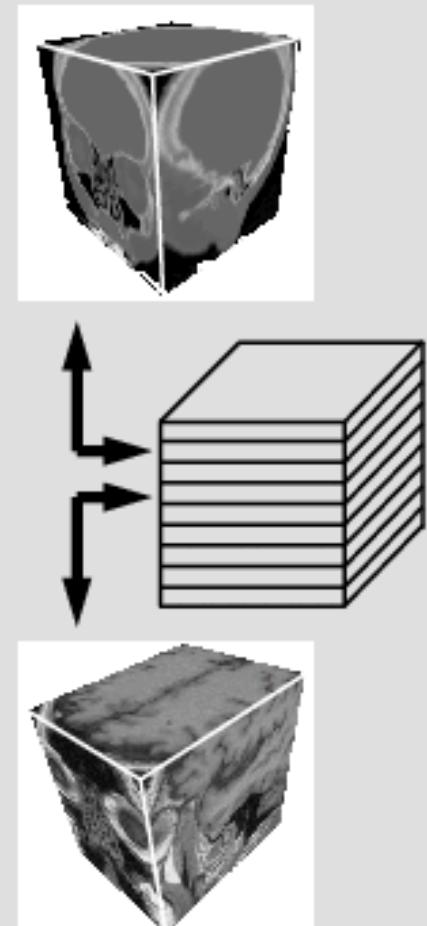
Read (optional):

- Paper:
Nelson Max, Optical Models for Direct Volume Rendering,
IEEE Transactions on Visualization and Computer Graphics, 1995
<http://dx.doi.org/10.1109/2945.468400>

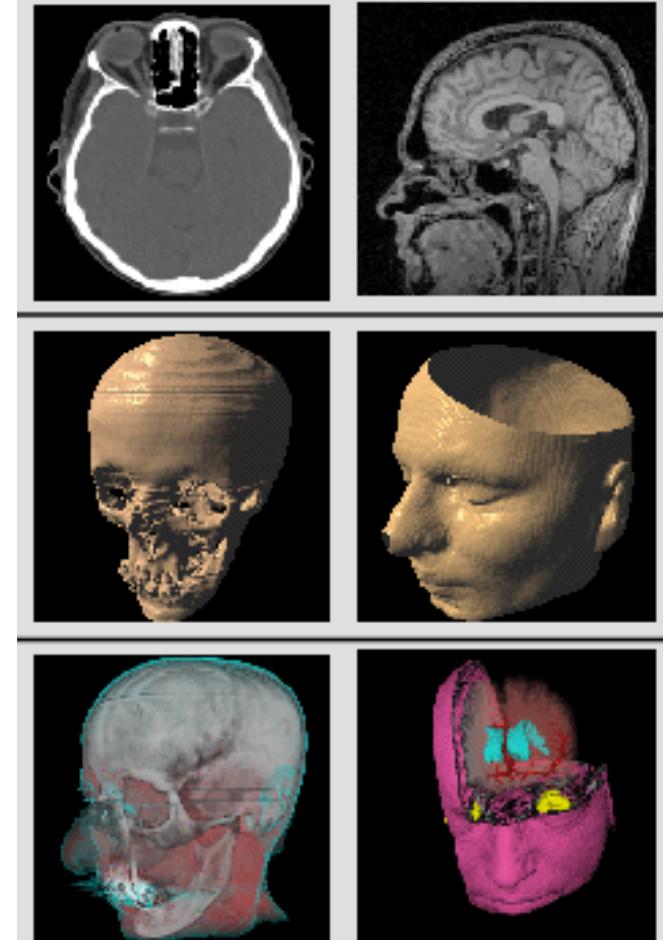
Volume Rendering

Theory

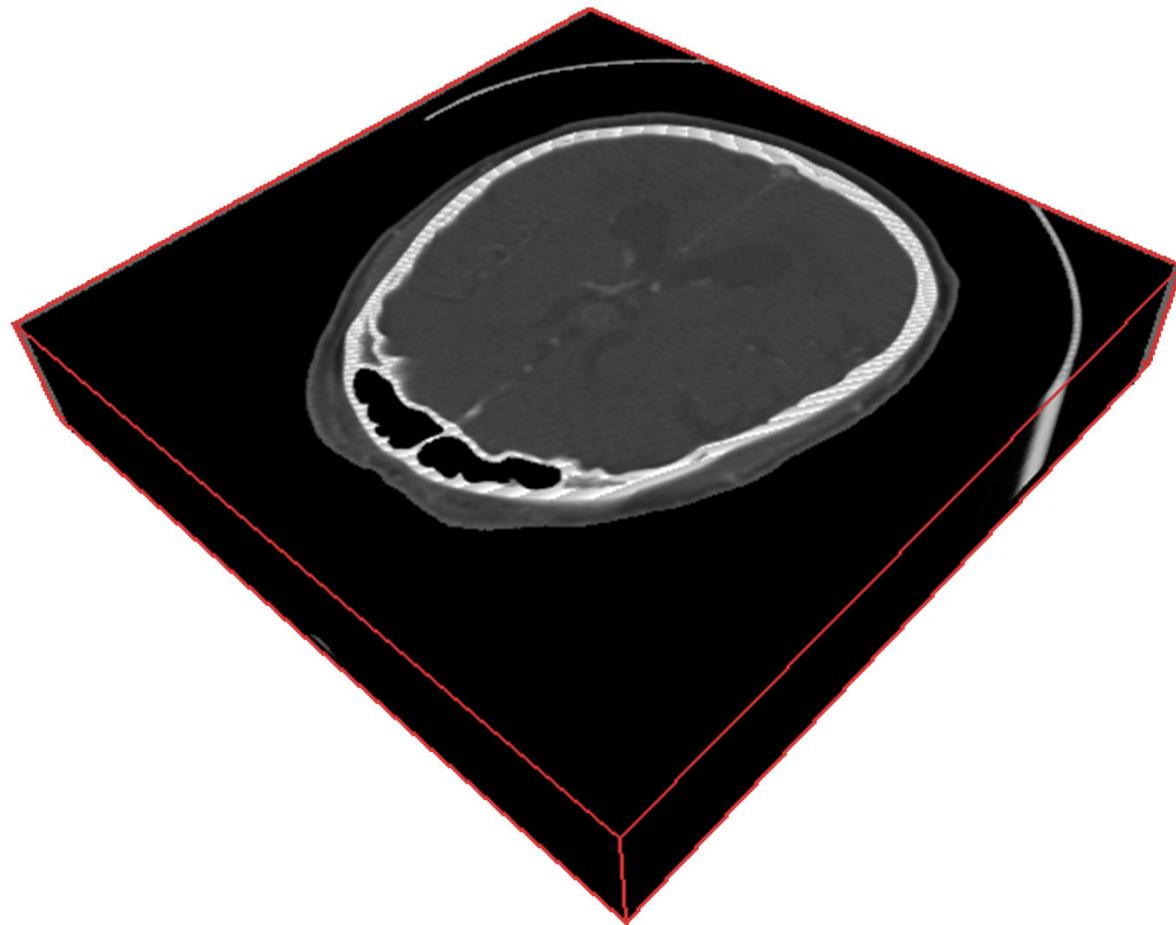
Volume Visualization



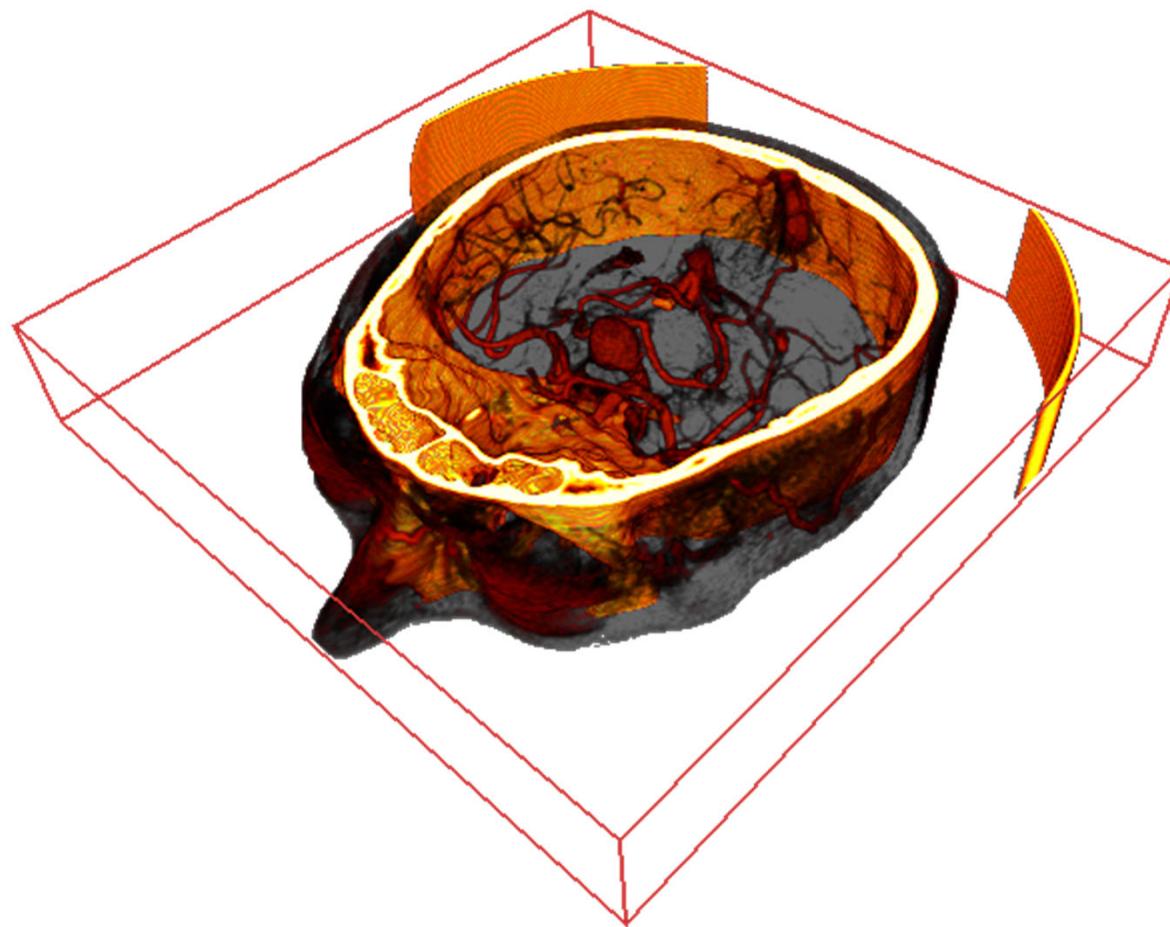
- 2D visualization
slice images
(or multi-planar
reformatting MPR)
- *Indirect*
3D visualization
isosurfaces
(or surface-shaded
display: SSD)
- *Direct*
3D visualization
(direct volume
rendering: DVR)



Direct Volume Rendering



Direct Volume Rendering

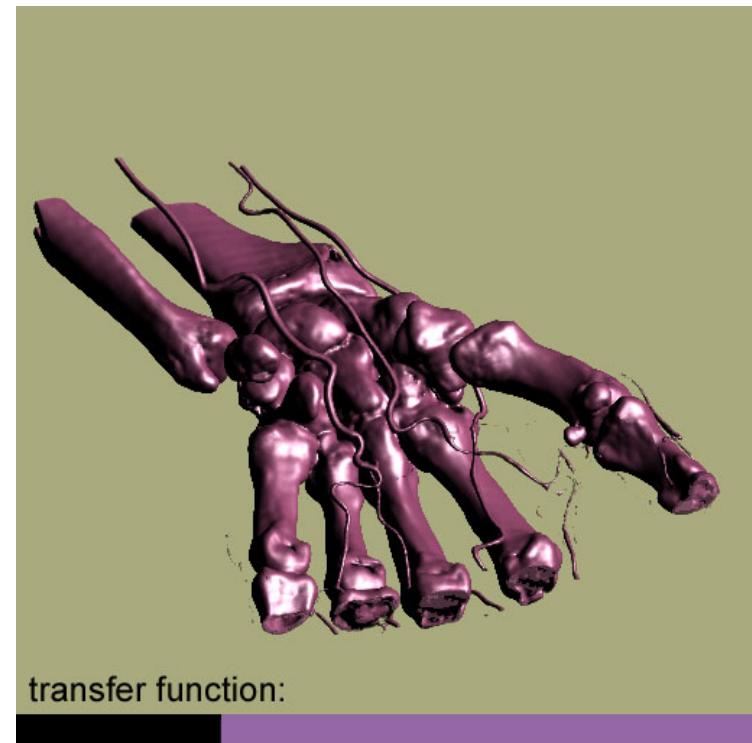
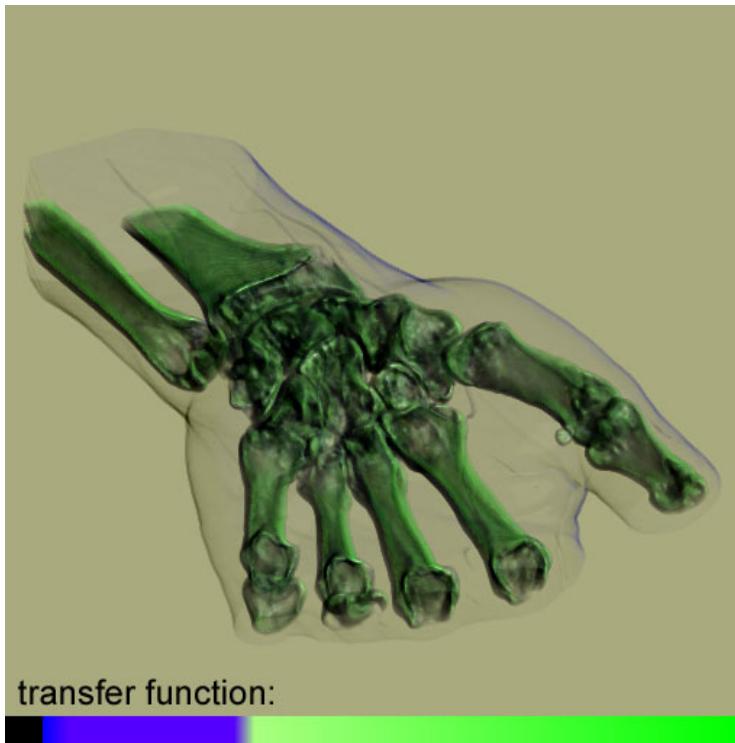


Transparent Volumes vs. Isosurfaces



The *transfer function* assigns *optical properties* to data

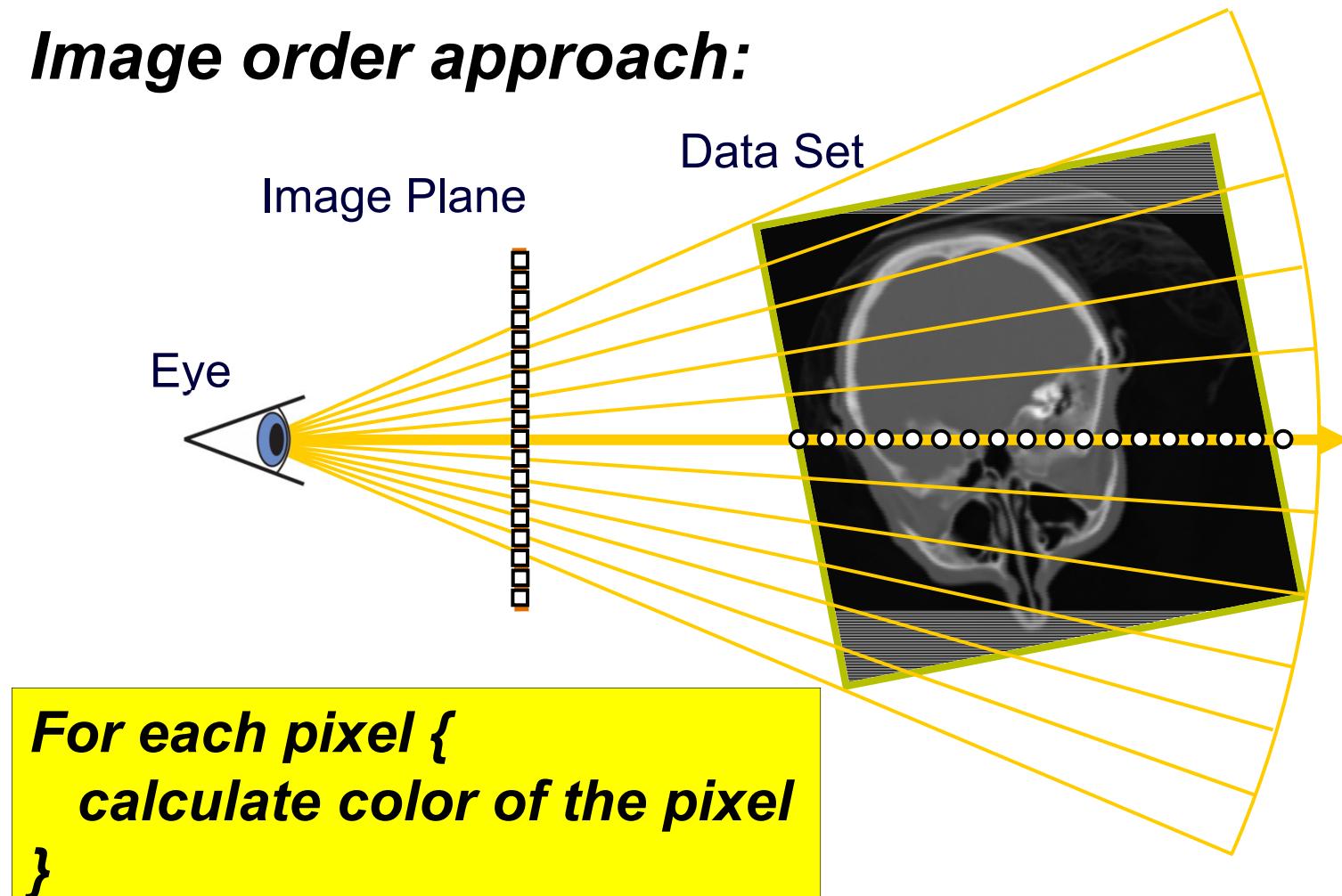
- Translucent volumes
- But also: isosurface rendering using step function as transfer function



Direct Volume Rendering: Image Order



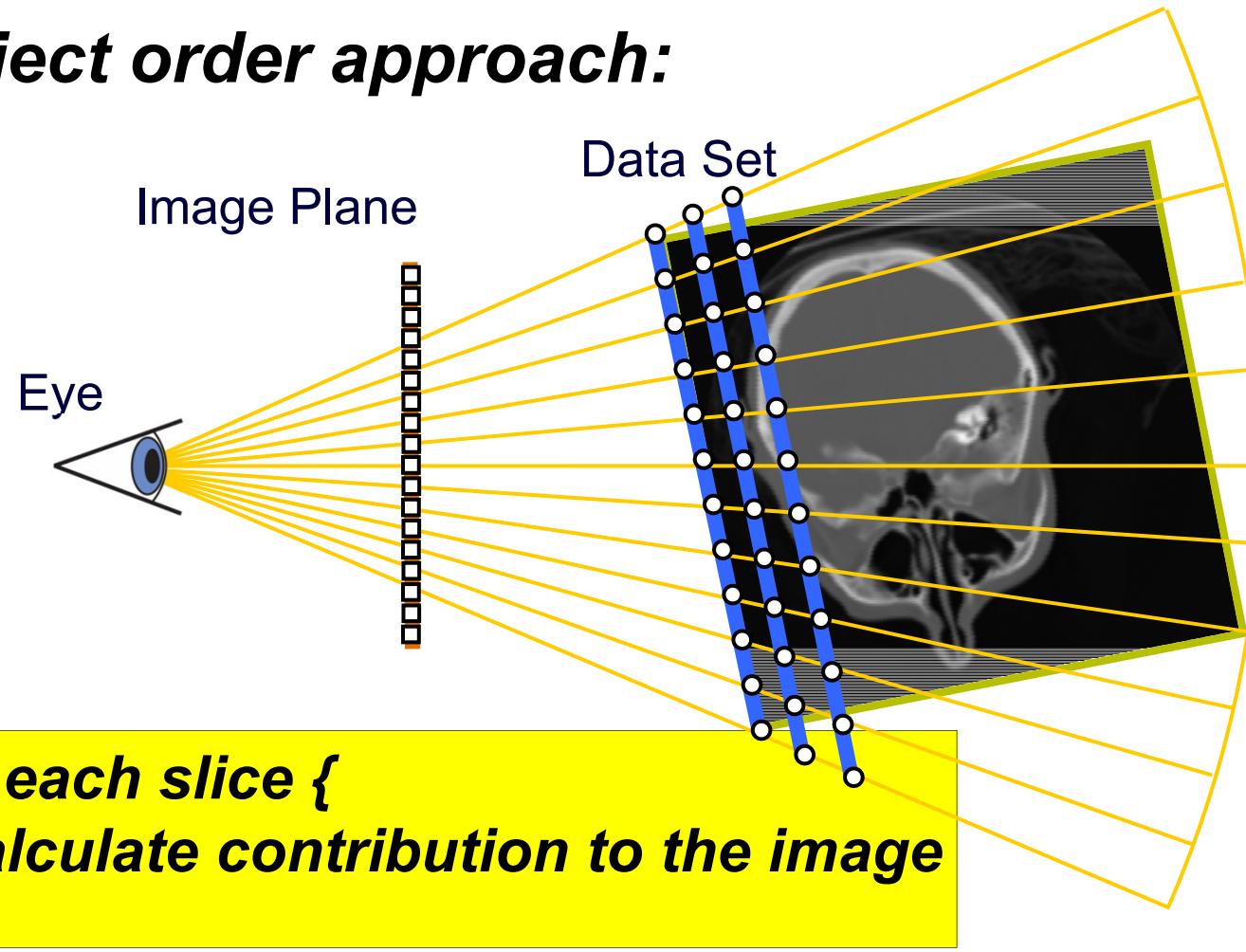
Image order approach:



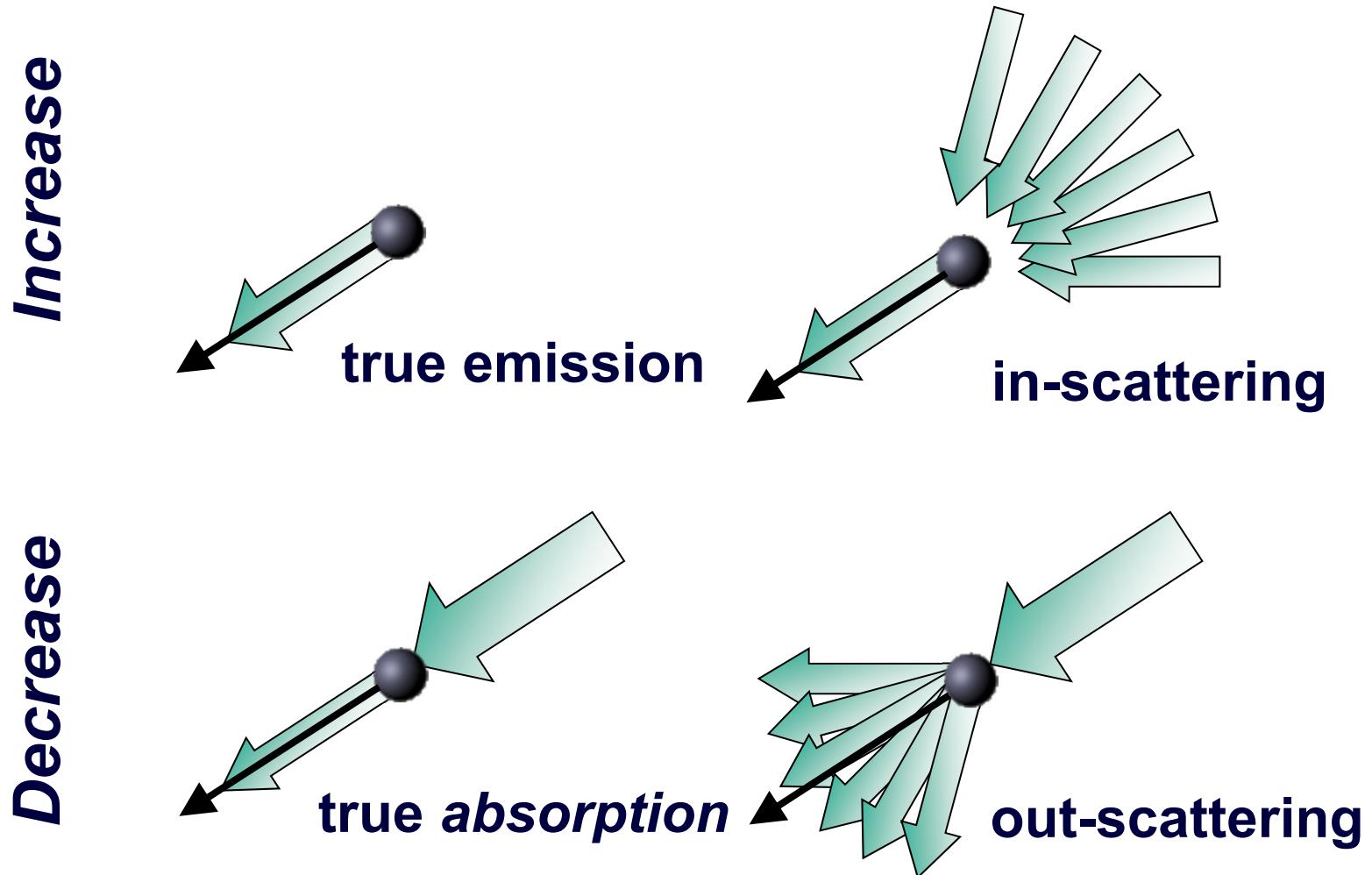
Direct Volume Rendering: Object Order



Object order approach:



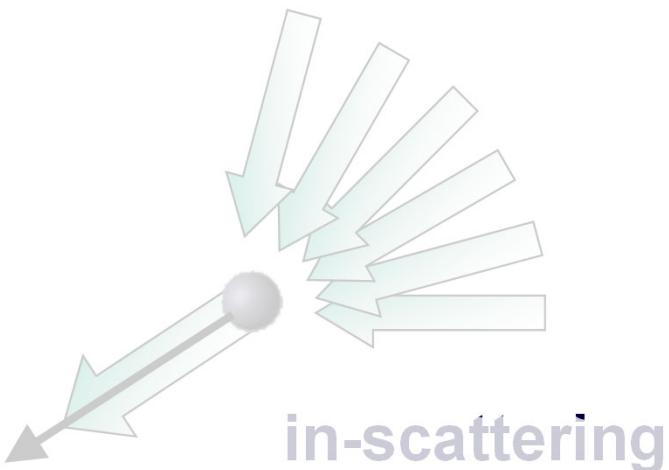
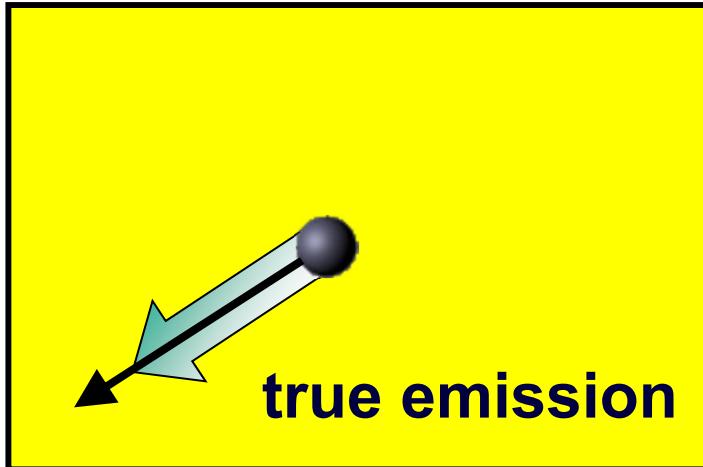
Physical Model of Radiative Transfer



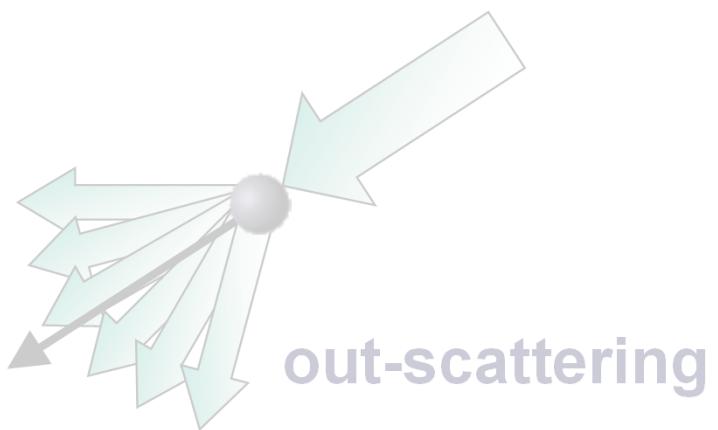
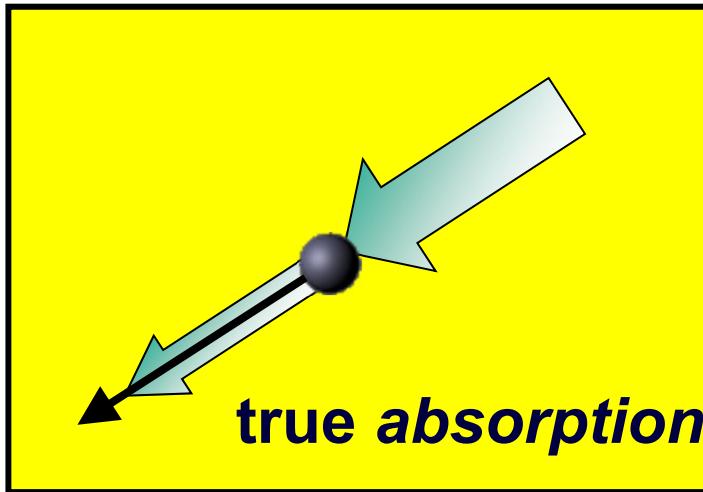
Physical Model of Radiative Transfer



Increase



Decrease



Optical Models: Physical Model gives ODE



Optical Models for Direct Volume Rendering, Nelson Max
Emission-Absorption optical model

$$\frac{dI}{ds} (s) = q(s) - \kappa(s) I(s)$$

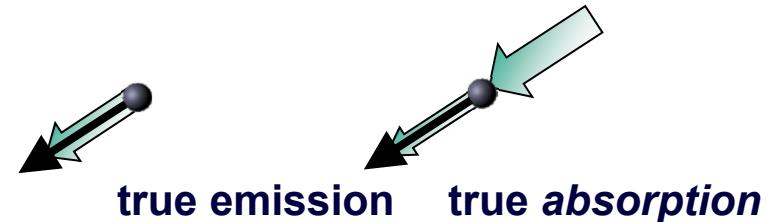


Right-hand side: *Rates of change* (derivatives) of light intensity along ray
Absorption rate is proportional to light intensity: Solution is exponential

Volume Rendering Integral



Volume rendering integral
for *Emission Absorption* model



$$I(s) = I(s_0) e^{-\tau(s_0, s)} + \int_{s_0}^s q(\tilde{s}) e^{-\tau(\tilde{s}, s)} d\tilde{s}$$

Iterative/recursive numerical solutions:

Back-to-front compositing

$$C'_i = C_i + (1 - A_i)C'_{i-1}$$

Front-to-back compositing

$$C'_i = C'_{i+1} + (1 - A'_{i+1})C_i$$

$$A'_i = A'_{i+1} + (1 - A'_{i+1})A_i$$

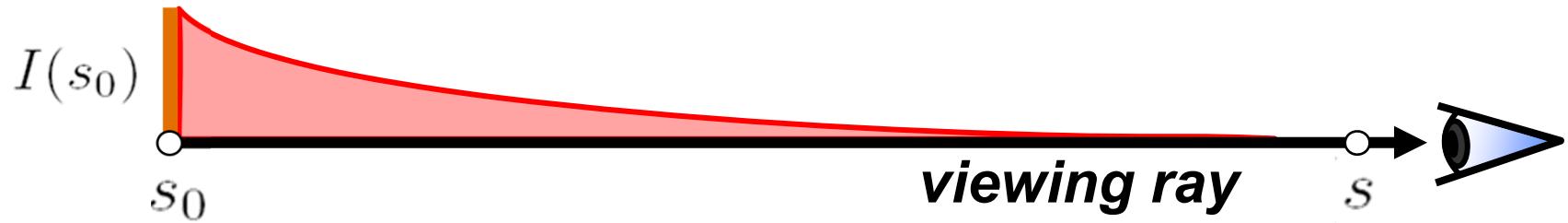
here, all colors are associated colors!

Volume Rendering Integral



How do we determine the radiant energy along the ray?

Physical model: emission and absorption, no scattering



Optical depth τ
Absorption κ

$$I(s) = I(s_0) e^{-\tau(s_0, s)}$$

$$\tau(s_1, s_2) = \int_{s_1}^{s_2} \kappa(s) ds.$$

Thank you.

Thanks for material

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