Illustrative Context-Preserving Volume Rendering

S.Bruckner, S.Grimm, A.Kanitsar, M.E.Gröller

Michal Červeňanský
cervenansky@sccg.sk

Overview

- Motivation
- Introduction
- Volume rendering model
- The Context-Preserving VR model
- Implementation
- Additional
- Results
- Conclusion

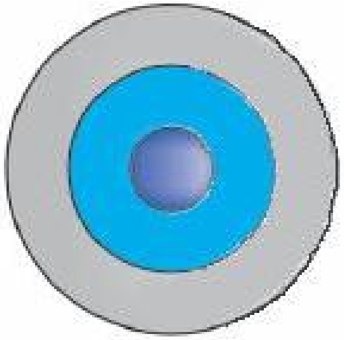
Motivation

- Interior and exterior structures – difficult
- TF – many internal parts are occluded
- Clipping – remove important information
- Grad. Modulation – many overlapping structures
- New model based on
  - shading
  - gradient
  - distances
  - accumulated op.

Volume Rendering model

- continuous volumetric scalar field
- front-to-back composition
- opacity, color contributions

$$\alpha_i = \alpha_{i-1} + \alpha(\mathbf{P_i}) \cdot (1 - \alpha_{i-1})$$
$$c_i = c_{i-1} + c(\mathbf{P_i}) \cdot \alpha(\mathbf{P_i}) \cdot (1 - \alpha_{i-1})$$



VR model - shading

- Shading – Phong-Blinn model

$$\alpha(\mathbf{P_i}) = \alpha_{tf}(f_{\mathbf{P_i}})$$
$$c(\mathbf{P_i}) = c_{tf}(f_{\mathbf{P_i}}) \cdot s(\mathbf{P_i})$$

$$s(\mathbf{P_i}) = c_d \cdot \left\|\hat{\mathbf{L}} \cdot \hat{\mathbf{g}}_{\mathbf{P_i}}\right\| + c_s \cdot \left(\left\|\hat{\mathbf{H}} \cdot \hat{\mathbf{g}}_{\mathbf{P_i}}\right\|\right)^{c_e} + c_a$$

- L – normalized light vector
- H – normalized half-way vector
- g_{Pi} – normalized gradient
- diffuse, specular, ambient coefficients
- specular exponent

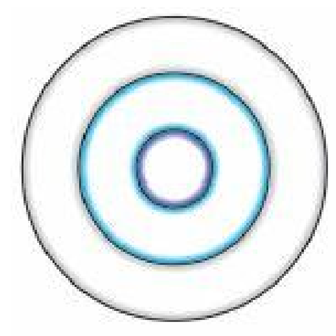
VR model – gradient modulation

- Gradient magnitude opacity modulation

$$\alpha(\mathbf{P_i}) = \alpha_{tf}(f_{\mathbf{P_i}}) \cdot \|\mathbf{g}_{\mathbf{P_i}}\|_{[0..1]}$$

- $\|\mathbf{g}_{\mathbf{P_i}}\|_{[0..1]}$ grad. mag. normalized to <0,1>

- boundaries enhancement

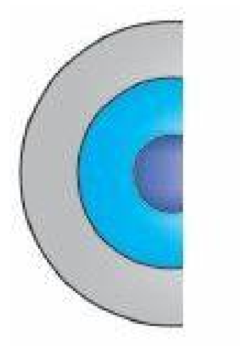


VR model – clipping plane

- View-aligned clipping plane

$$\alpha(\mathbf{P_i}) = \begin{cases} 0 & (\mathbf{P_i} - \mathbf{E}) \cdot \hat{\mathbf{V}} < d \\ \alpha_{tf}(f_{\mathbf{P_i}}) & \text{otherwise,} \end{cases}$$

- E - eye point
- V - normalized viewing direction
- d - depth of the clipping plane



The Context-Preserving VR model

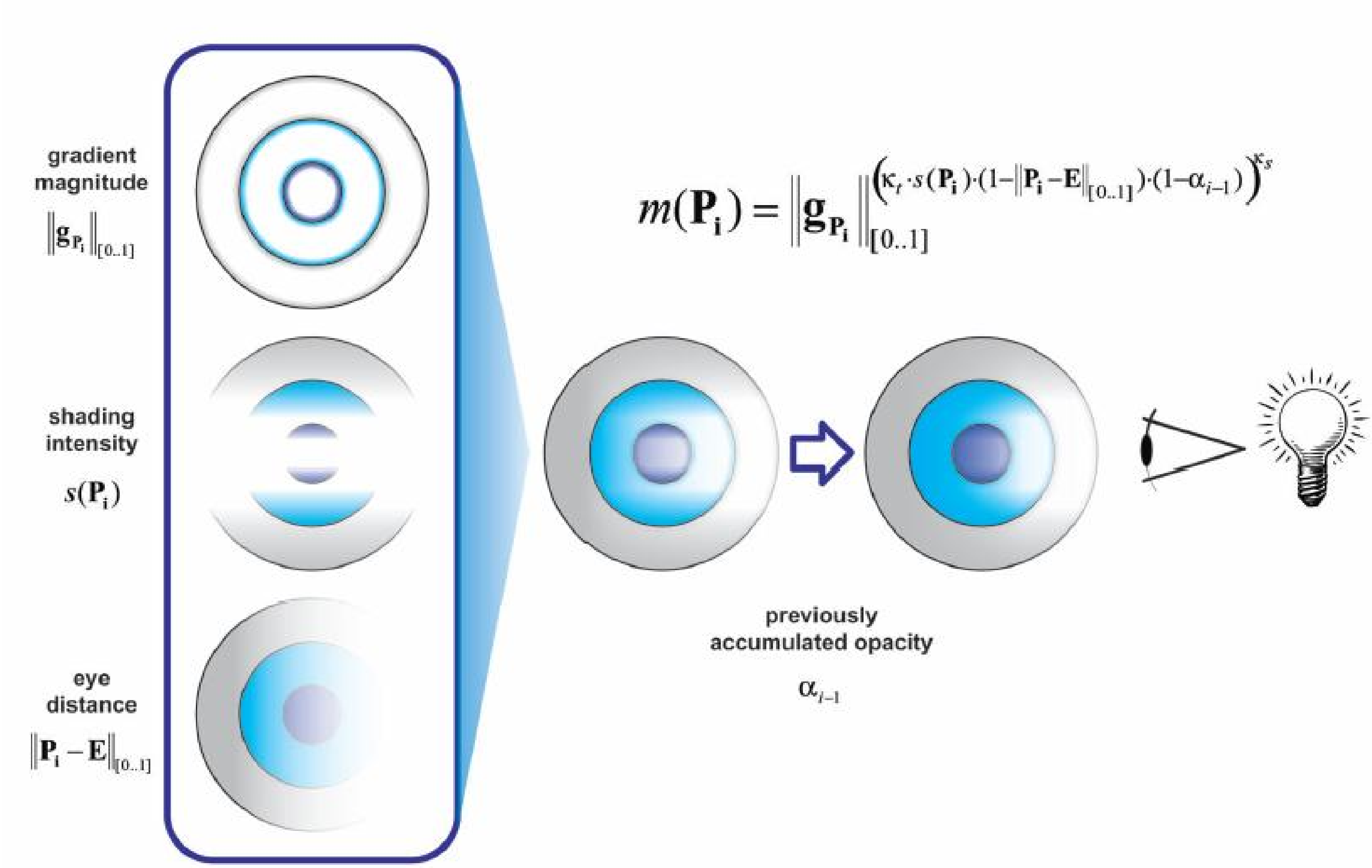
- Combination various VR models

$$\alpha(\mathbf{P_i}) = \alpha_{tf}(f_{\mathbf{P_i}}) \cdot m(\mathbf{P_i})$$

$$m(\mathbf{P_i}) = \|\mathbf{g}_{\mathbf{P_i}}\|_{[0..1]}^{\left(\kappa_t \cdot s(\mathbf{P_i}) \cdot (1 - \|\mathbf{P_i} - \mathbf{E}\|_{[0..1]}) \cdot (1 - \alpha_{i-1})\right)^{\kappa_s}}$$

- User defined parameters k_t, k_s
- k_t - depth of clipping plane
- k_s - sharpness (clipped / visible regions)
- k_t k_s - data dependent, TF
- k_t k_s - set to 0 → DVR / Grad. Modulation

The Context-Preserving VR model (2)

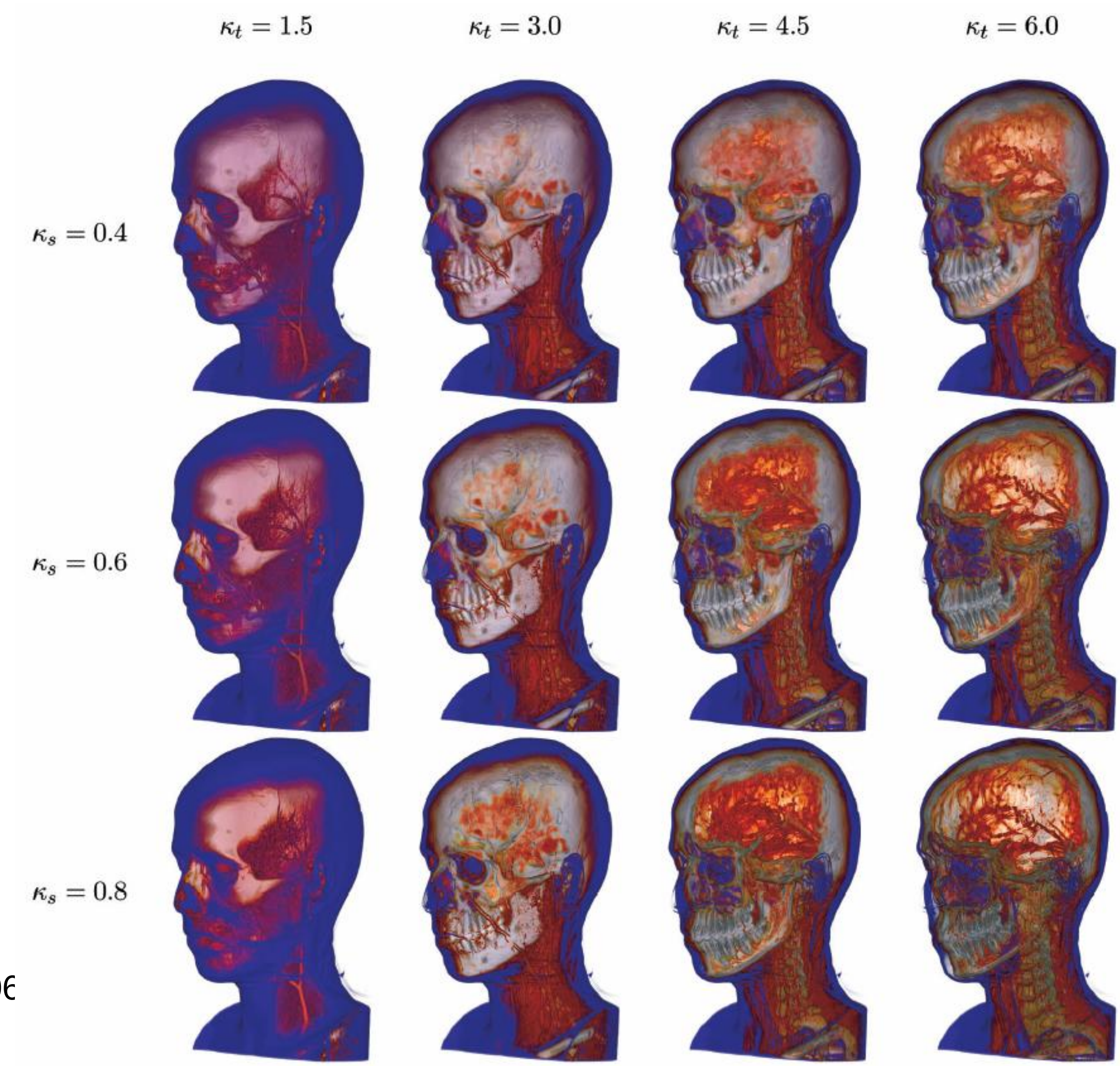


Implementation

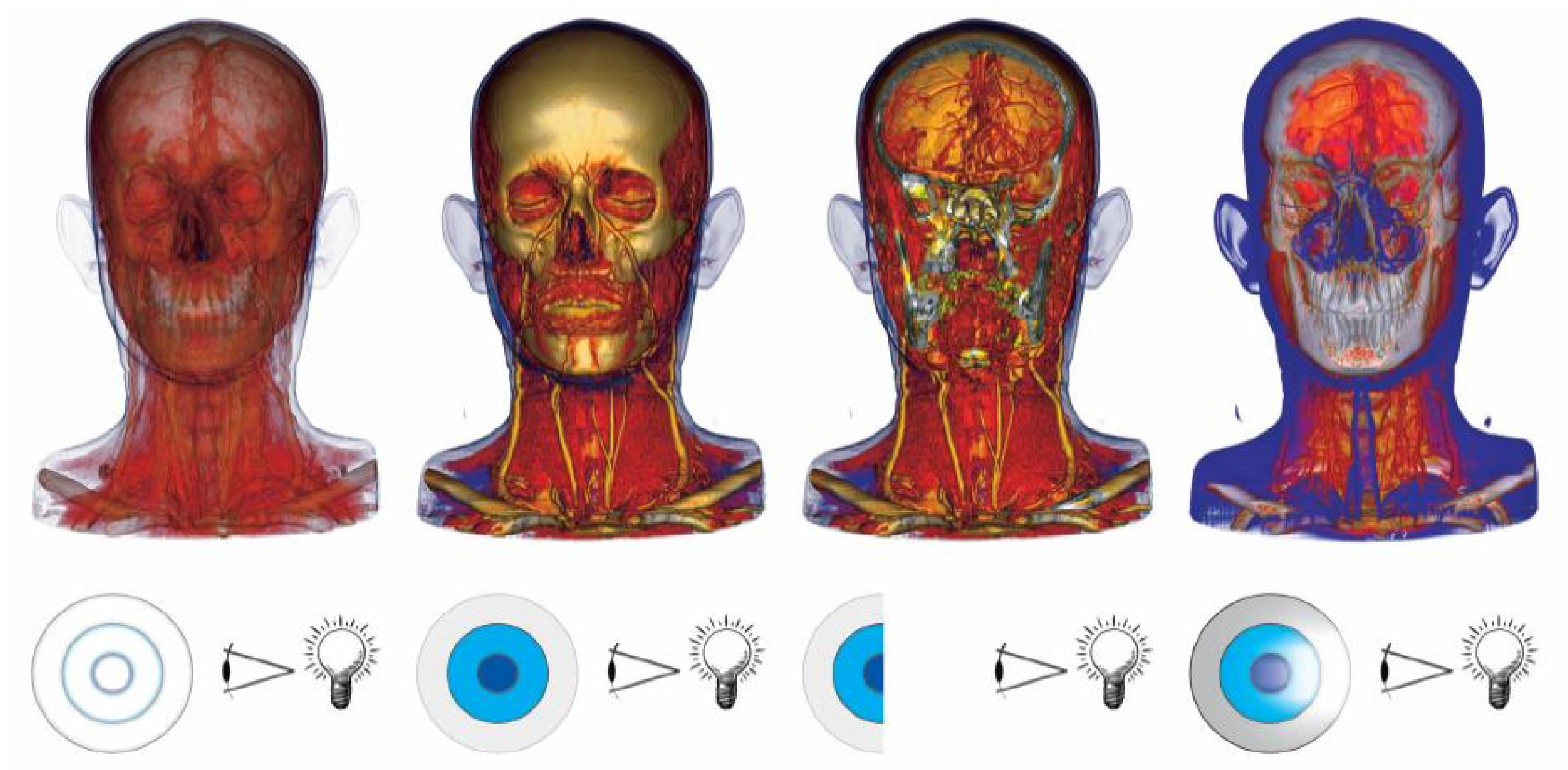
- straight-forward
- gradient direction, magnitude
- depth along viewing ray
- compatible with standard acc. techniques
- approximation

$$(a \cdot y)^b \approx \frac{x \cdot (b + ay - aby)}{ay + b \cdot (x - axy)}$$

Results


$\kappa_t = 1.5$
$\kappa_t = 3.0$
$\kappa_t = 4.5$
$\kappa_t = 6.0$
$\kappa_s = 0.4$
$\kappa_s = 0.6$
$\kappa_s = 0.8$

Results (2)



Additional

- Illustrative Context-Preserving Exploration of Volume Data
- GPU implementation
- Multiple lights

$$c(\mathbf{P_i}) = c_{tf}(f_{\mathbf{P_i}}) \cdot \sum_{j=0}^{N-1} s_j(\mathbf{P_i})$$

$$m(\mathbf{P_i}) = \prod_{j \in T} \|\mathbf{g_{P_i}}\|_{[0..1]}^{\left(\kappa_{t_j} \cdot s_j(\mathbf{P_i}) \cdot (1 - \|\mathbf{P_i} - \mathbf{E}\|_{[0..1]}) \cdot (1 - \alpha_{i-1})\right)^{\kappa_{s_j}}}$$

Conclusion

- TF easier specification
- Intuitive control
- Interior examining
- Preserve context inf.
- No need segmentation
- Easy integration (CPU/GPU)

Thank you for your attention

References

- S. Bruckner, S. Grimm, A. Kanitsar, and M.E. Gröller, "Illustrative Context-Preserving Volume Rendering," *Proc. EuroVis '05, 2005*

- S. Bruckner, S. Grimm, A. Kanitsar, and M.E. Gröller, "Illustrative Context-Preserving Exploration of Volume Data", *IEEE Transactions on Visualization and Computer Graphics, 2006*