Two-level Volume Rendering – fusing MIP and DVR

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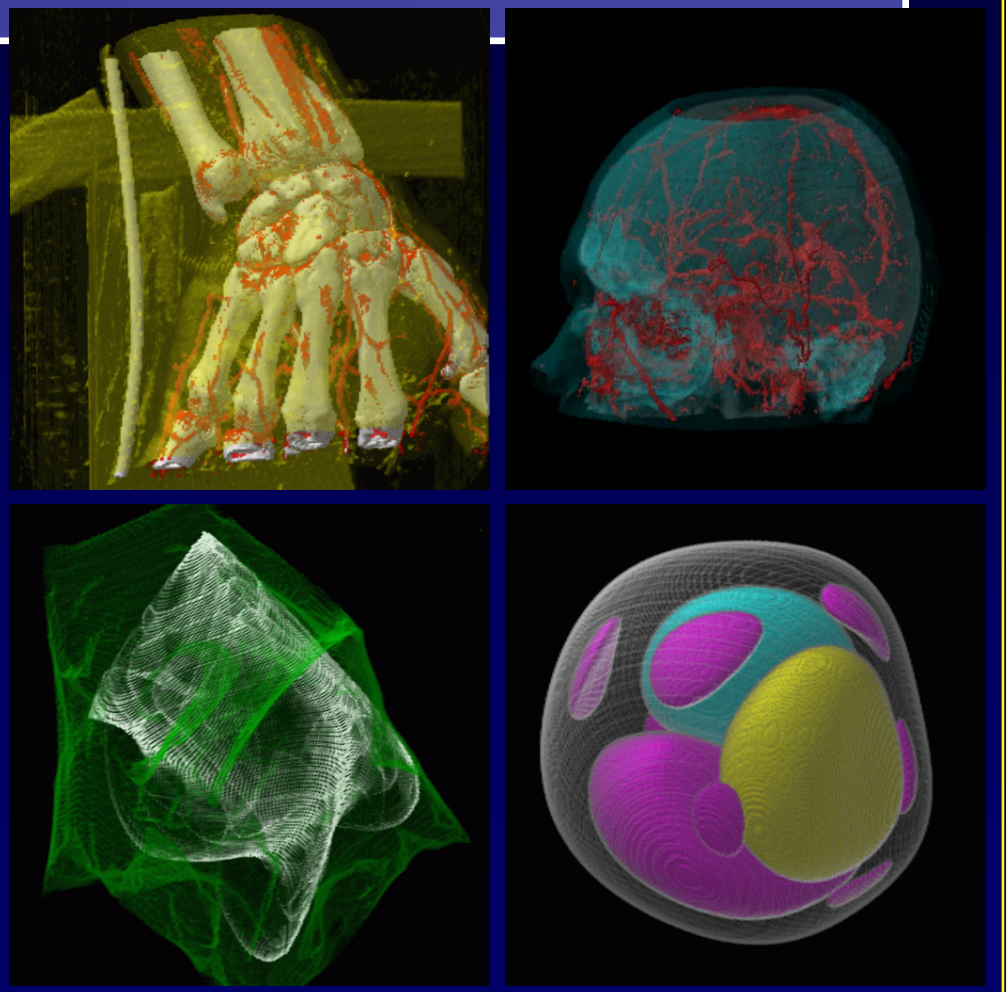


Introduction

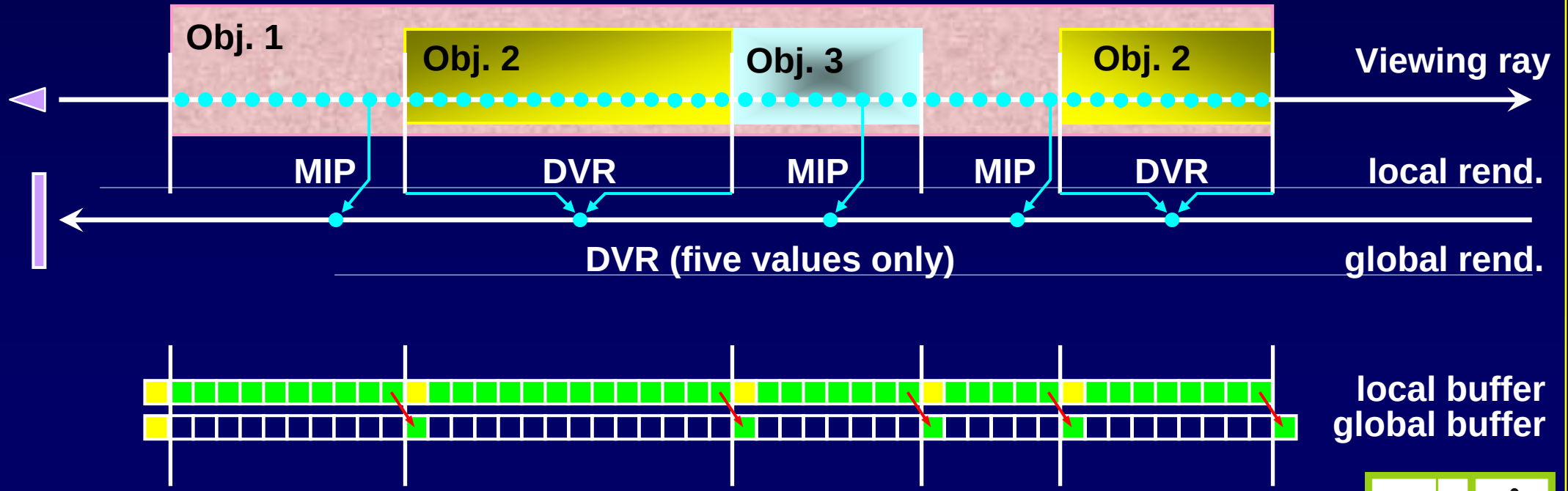
Volume Rendering:

- Goal: insight into 3D data
- Challenge: rendering projection
- Good solutions: DVR, MIP, etc. (different advantages)
- Best approach depends on:
  - Data, structure of data
  - User, visualization goals (regular goal: focus'n'context vis.)
- Logical: combinations of texs., like hybrid-rendering (surfs./DVR)

Two-level Volume Rendering

Basic Idea:

- Prerequisite: segmentation into objects
- Local rendering, object-by-object
- Global combination of representatives



Two-level Vol.-Rend. – Example

Bones, vessels: DVR

- rather binary transfer functions
- good 3D impression

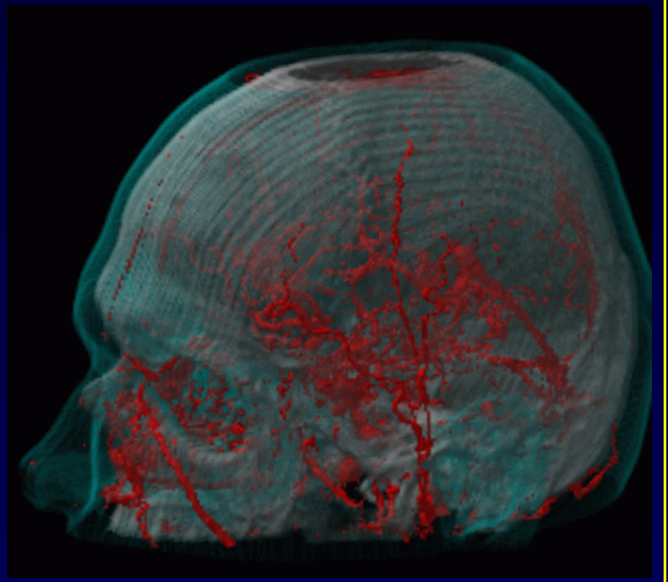
Skin: MIP

- rarely occluding
- useful context

Comparing DVR and MIP

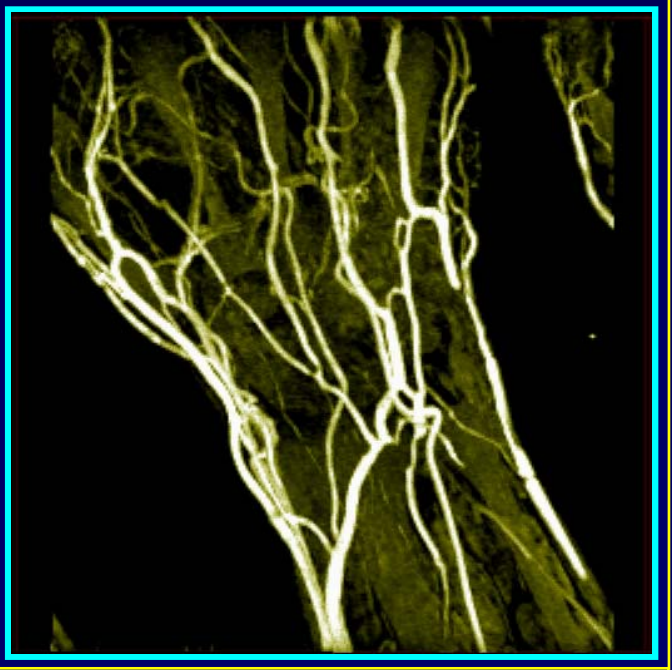
DVR:

- strong influence: “thickness”
- spec. of TFs.: difficult
- practical use: like surf. rend.
- 3D impression, but occlusion



MIP:

- clear, sharp images (flat?!), one struct. of interest only
- good for complex objects
- view-point variations needed
- wasting visual bandwidth?



Application: MIP for context

Focus and Context:

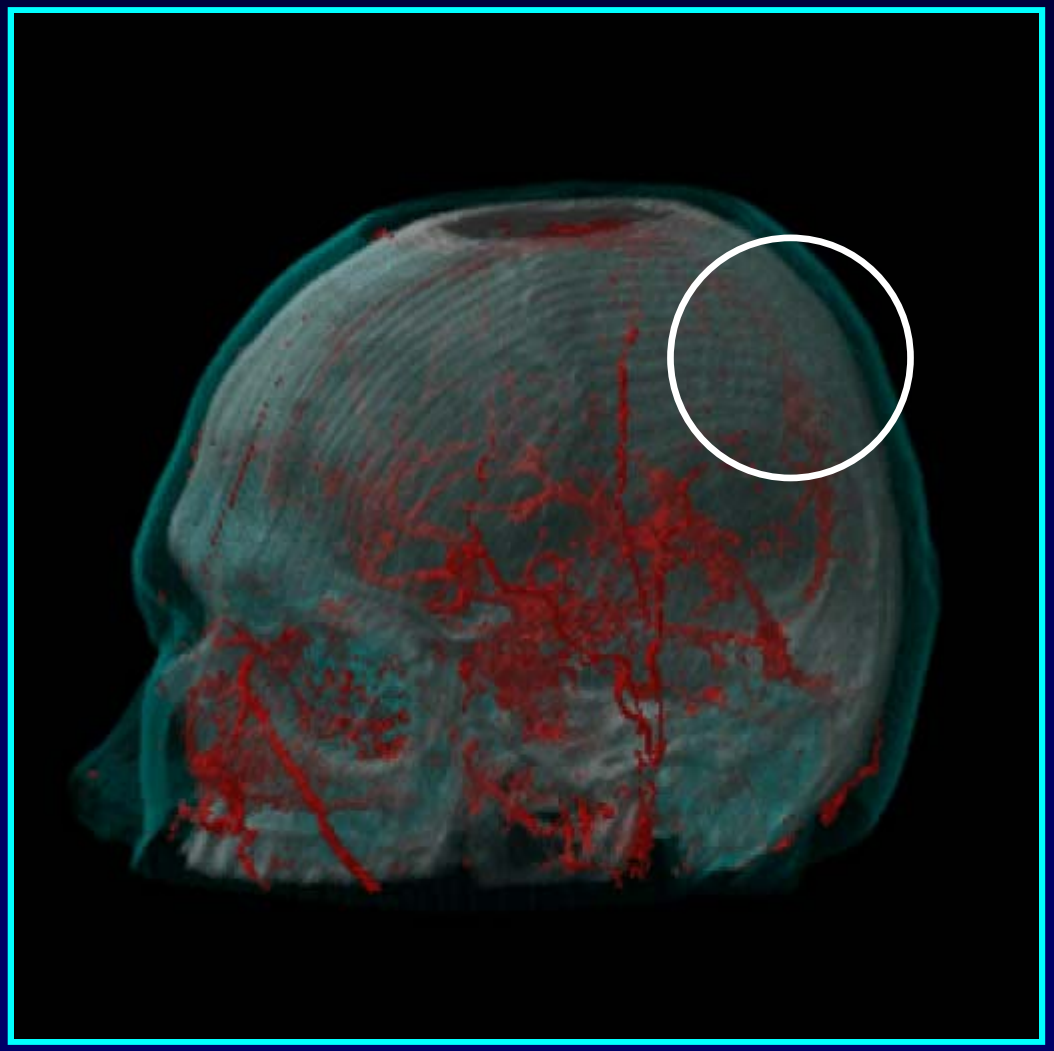
- well-known from information visualization
- often part of user goal (orientation)
- context should not distract, occlude view

Features of MIP:

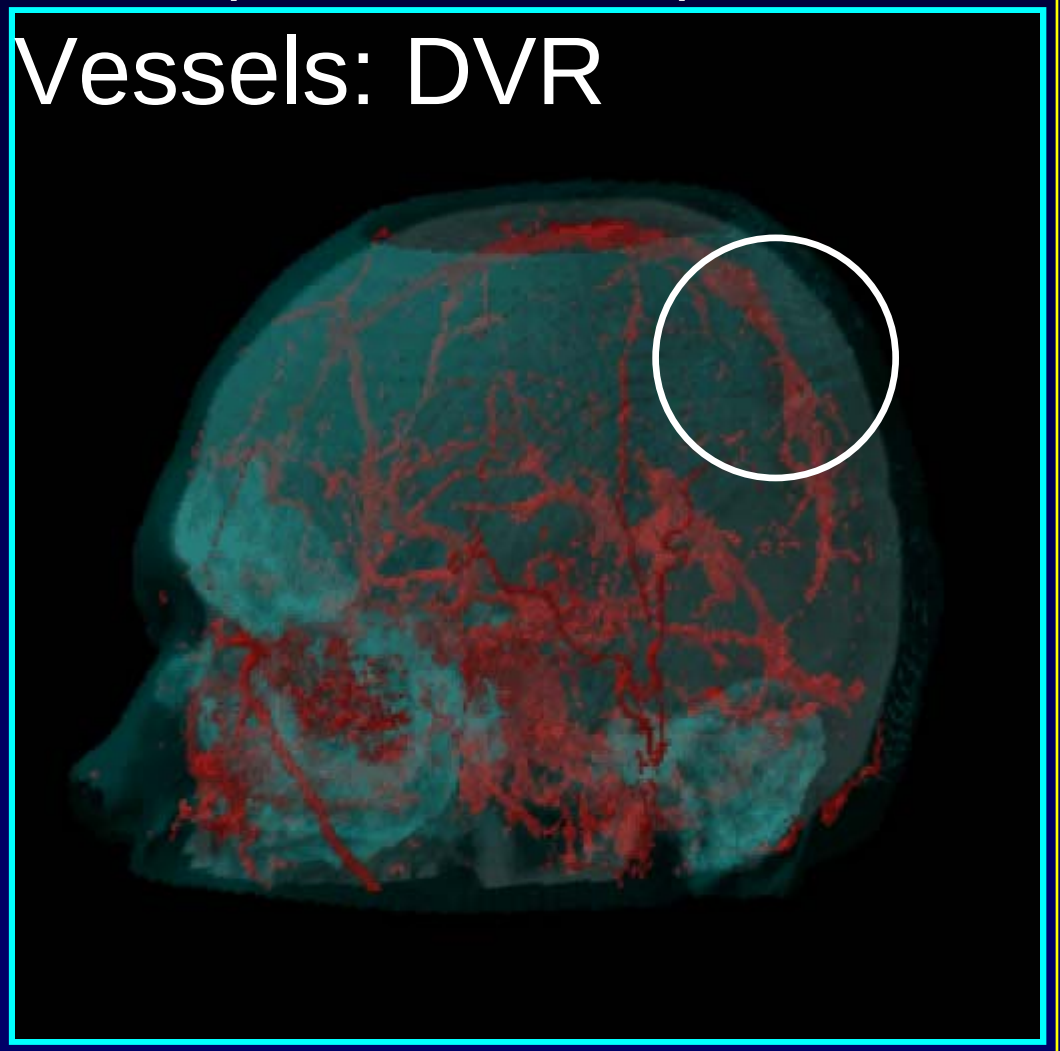
- 1 voxel thick everywhere $\Rightarrow$ easy-to-control transparency
- concentrates on values of importance (proper transfer function needed)

DVR vs. 2lVR 1/3

All: DVR

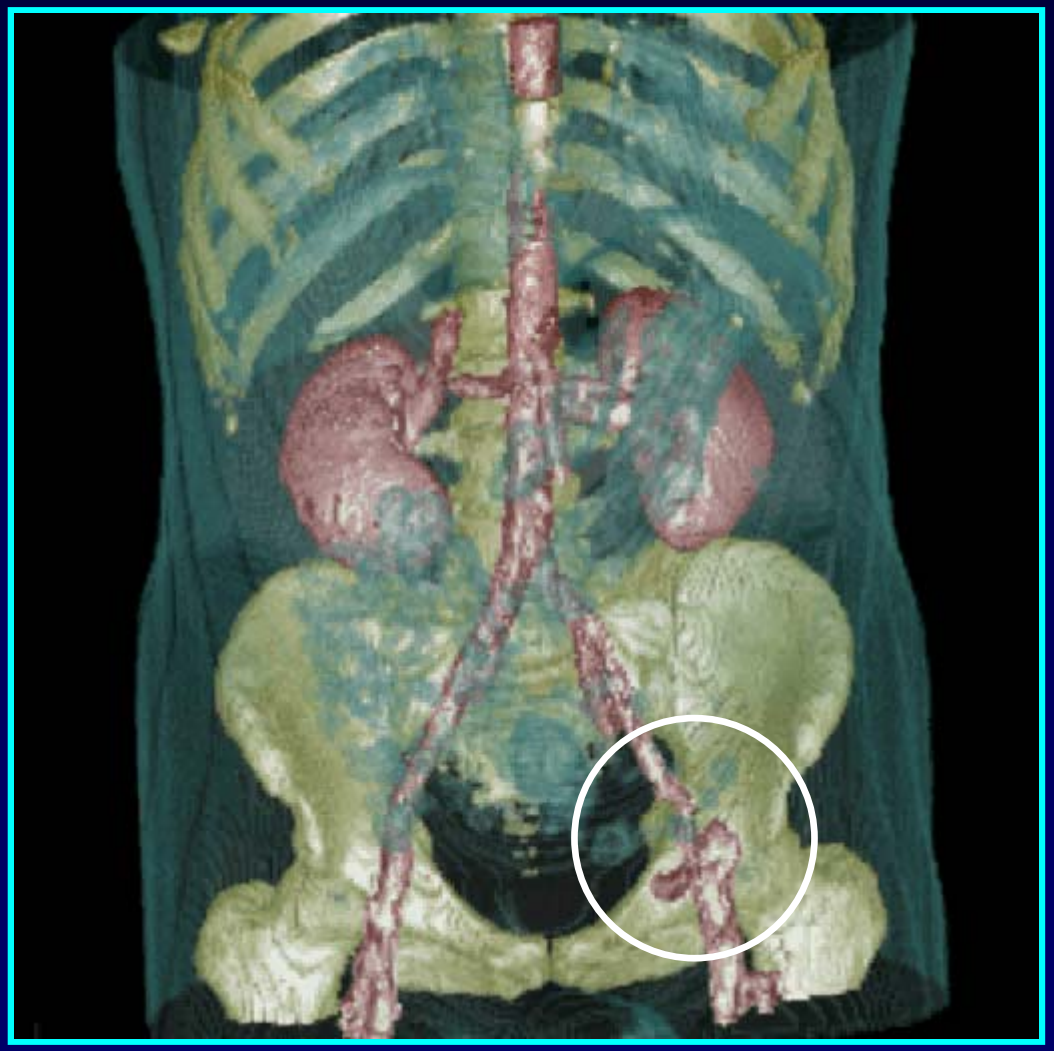


Skull, skin: MIP;
Vessels: DVR

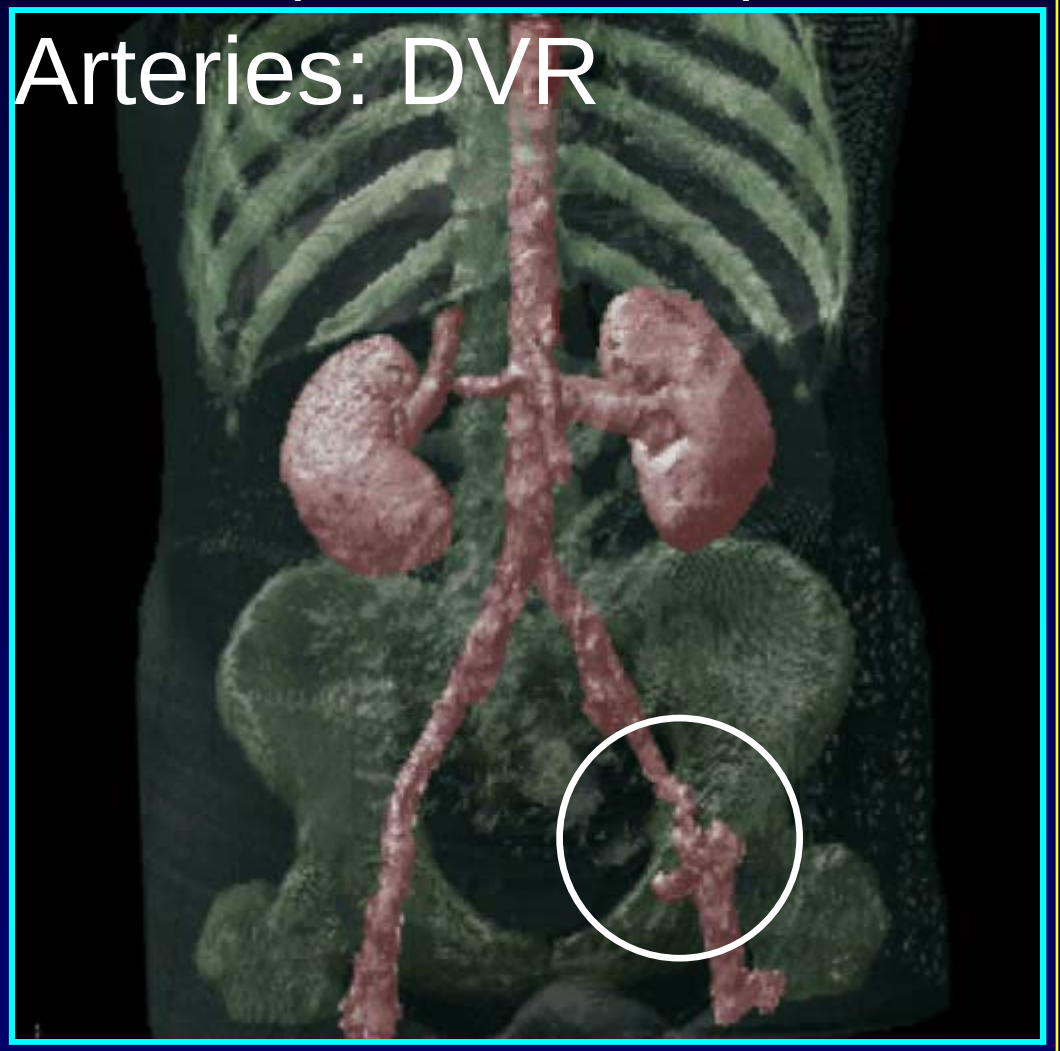


DVR vs. 2lVR 2/3

All: DVR

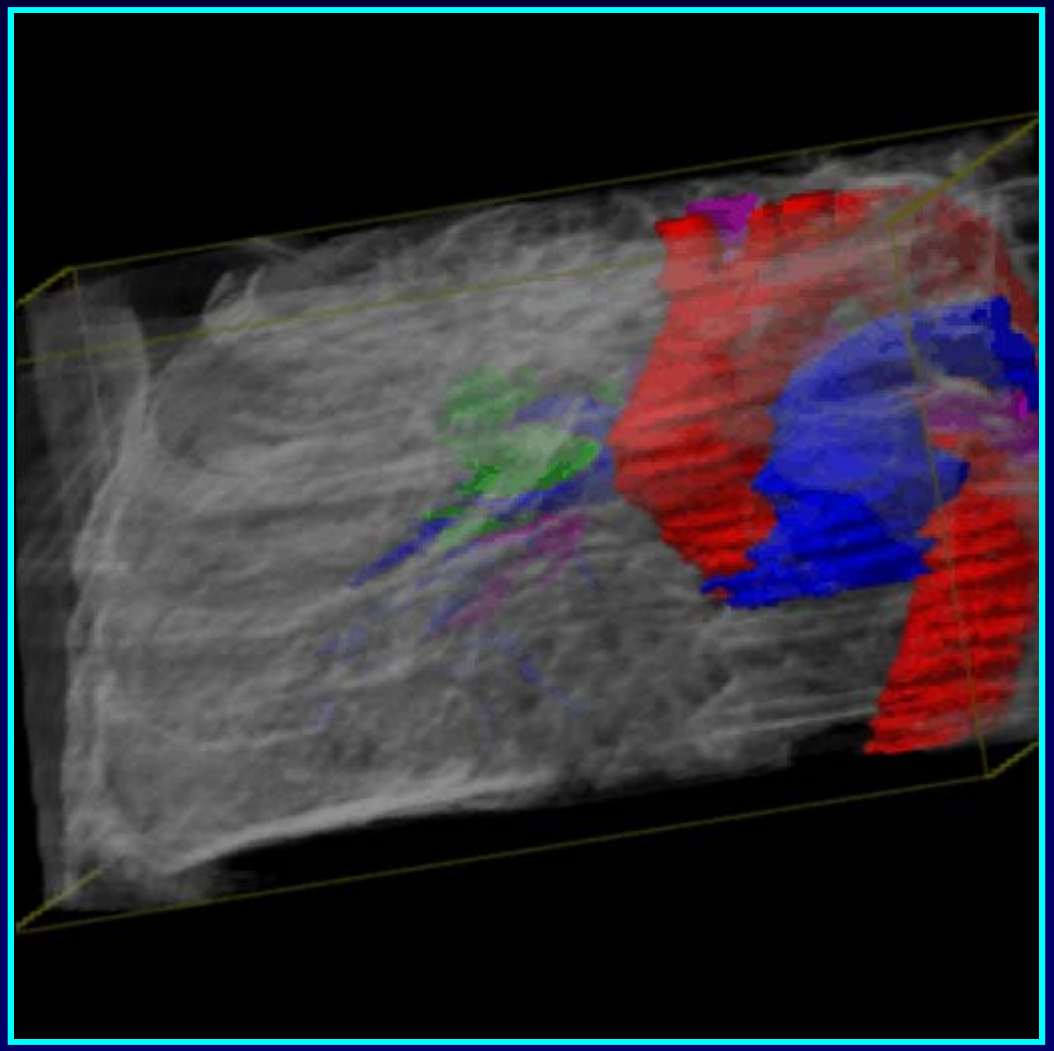


Bones, skin: MIP;
Arteries: DVR

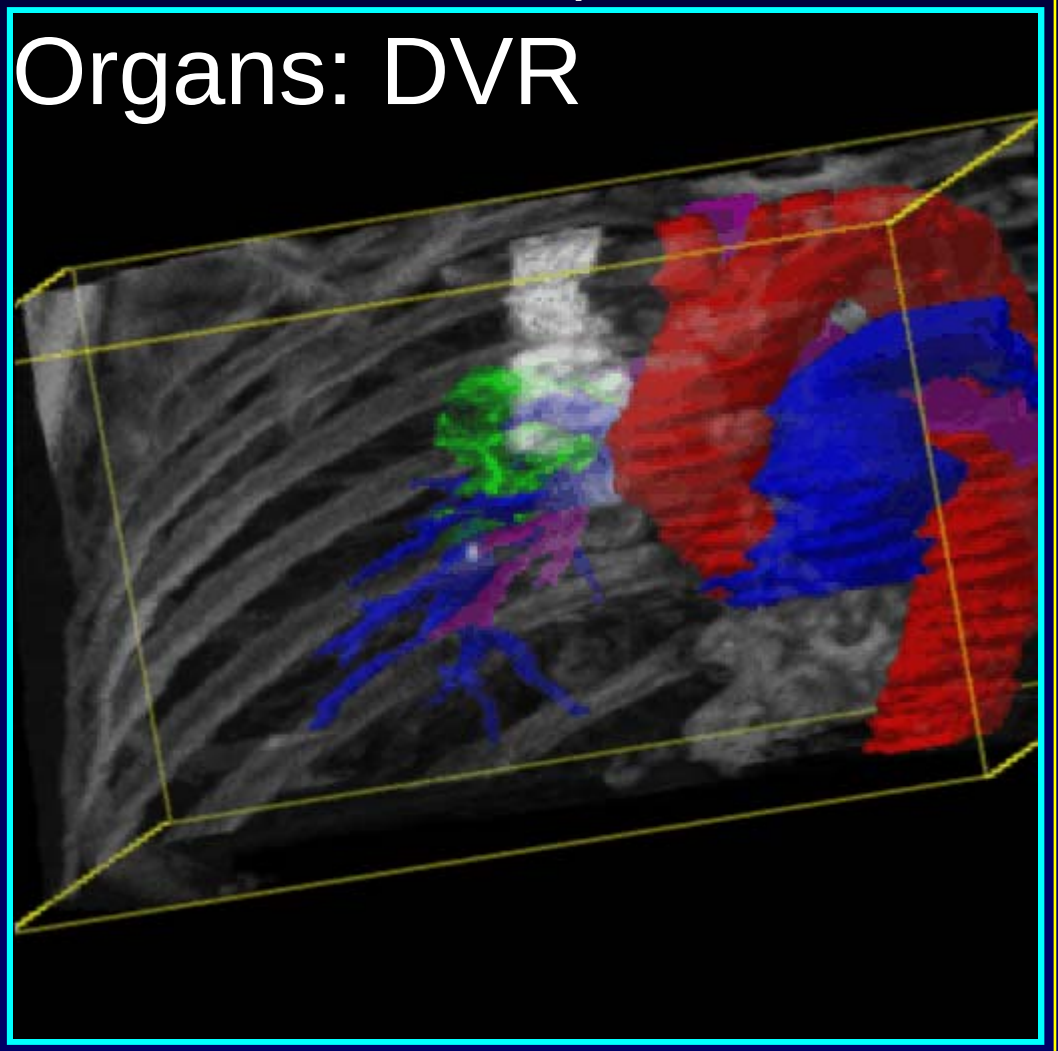


DVR vs. 2lVR 3/3

All: DVR



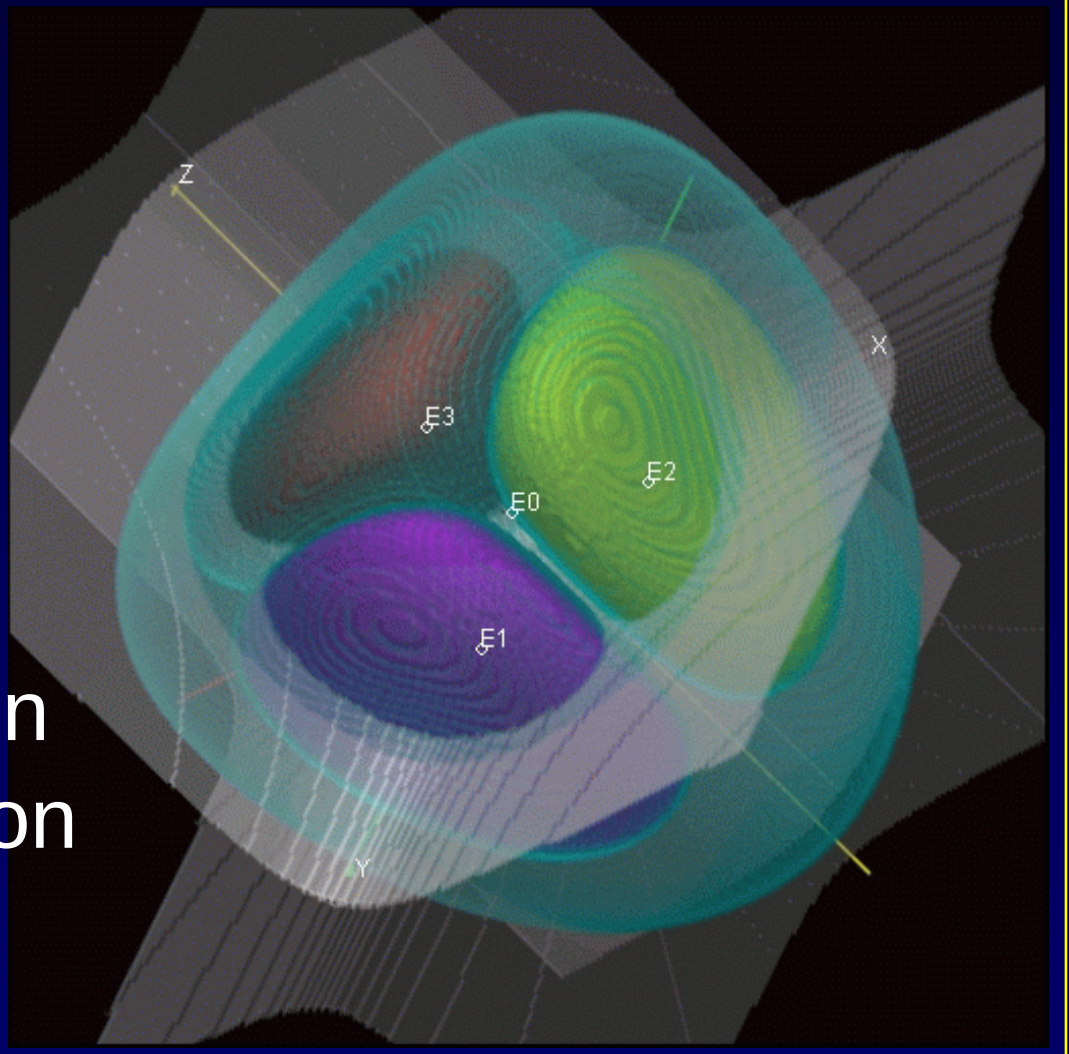
Context: MIP;
Organs: DVR



Dynamical System Visualization

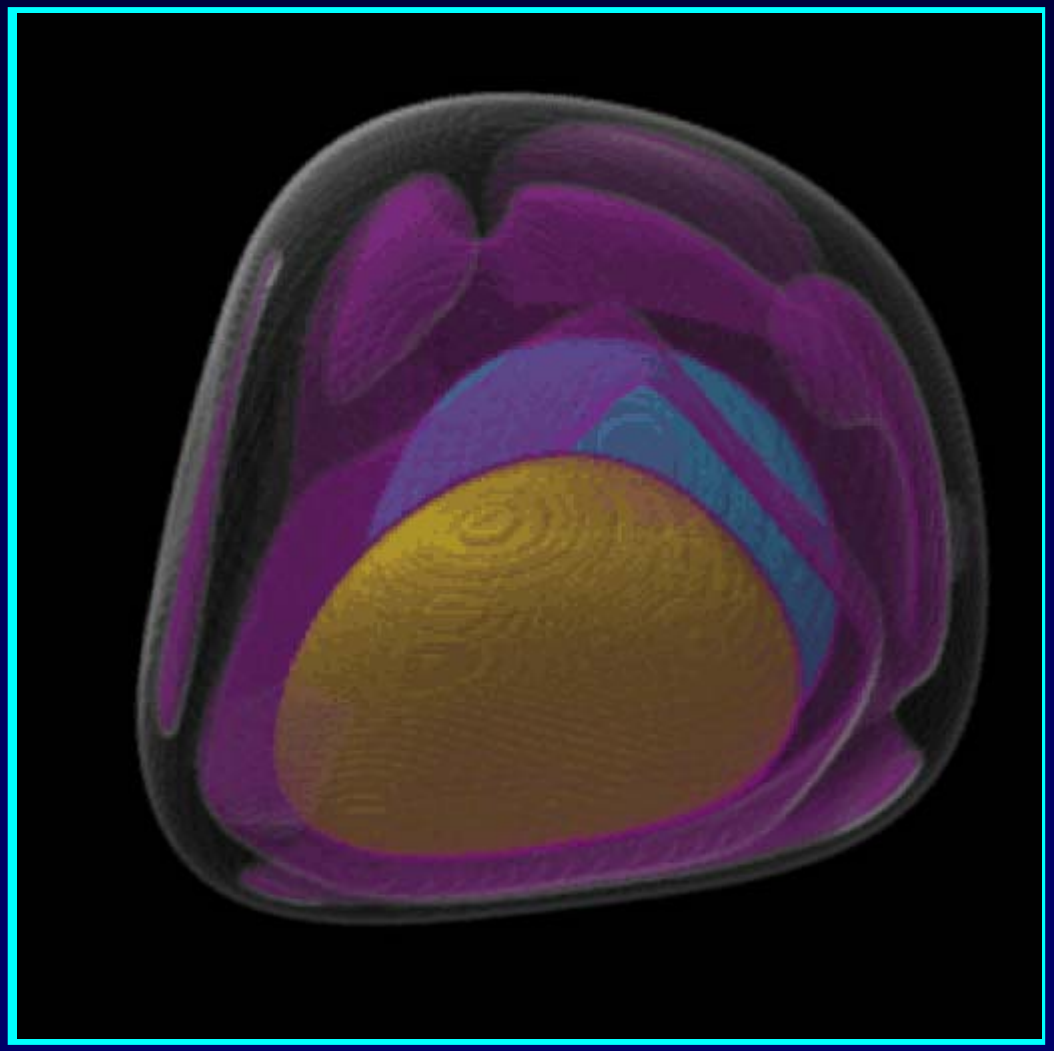
Original Application:

- game theory, econometrics
- discrete dynamical systems (maps)
- focus on:
  - attractors
  - basins of attraction
  - spatial inter-relation of basins
  - critical surfaces

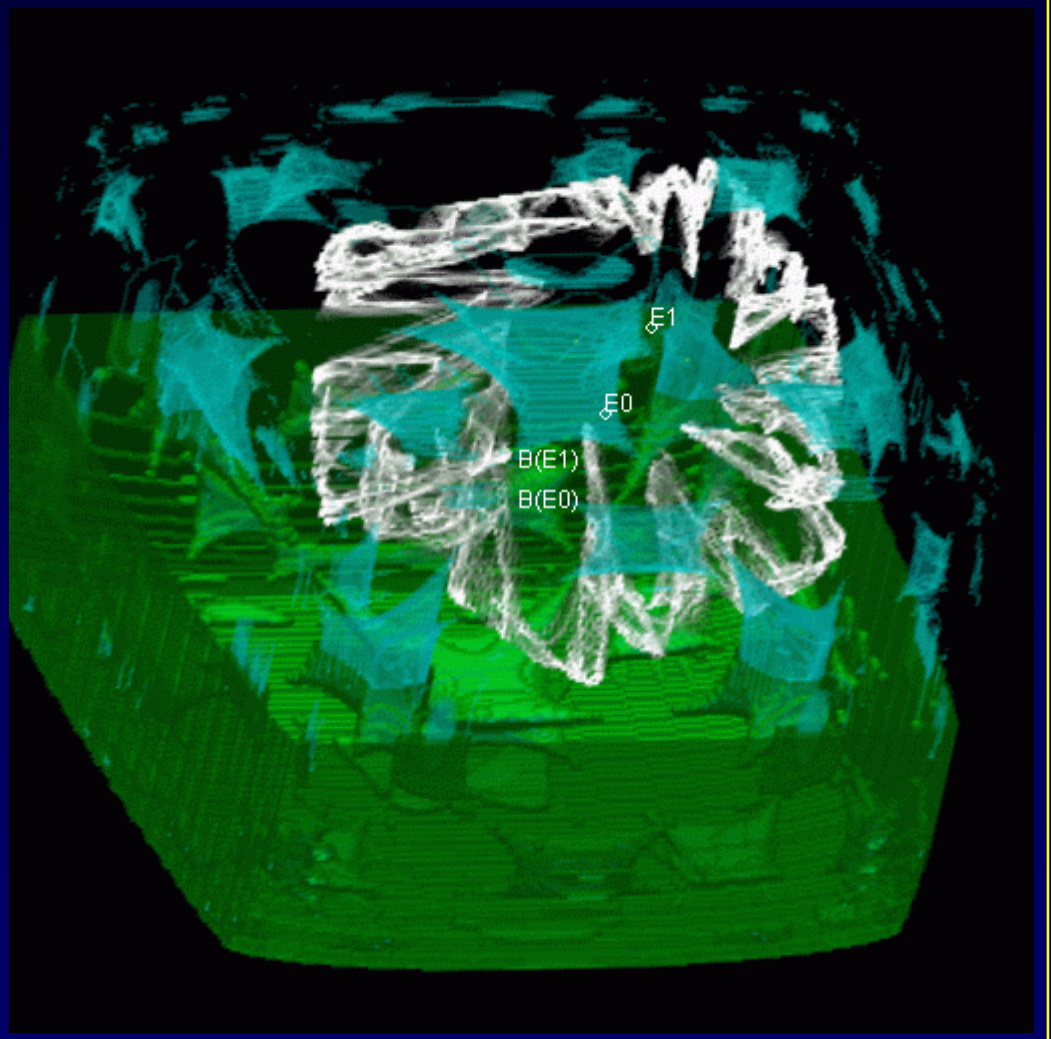


Two-level Volume Rendering

Outer basin: MIP



Attractor: MIP



Interactive Rendering 1/2

Shear-warp rendering:

- no inter-voxel interpolation $\Rightarrow$ fast!
- intermediate plane: two buffers (local, global)
- bi-linear warp

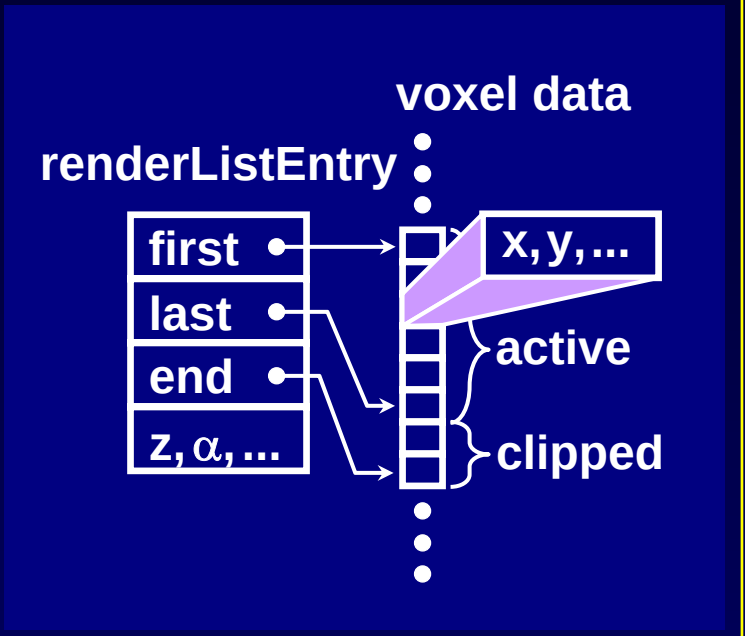
Reversed storage scheme:

- objects: stack of slices (varying z)
  slice: list of voxels (explicit x, y, etc.)
- re-ordering within slice: arbitrary clipping
- preprocessing, 3 copies of data: x, y, z

Interactive Rendering 2/2

renderListEntry[pvd**,**obj**,**z**]:**

- list of all voxels of obj. **obj**
- which share depth value **z** (principal viewing dir. **pvd**)
- object-opacity, z, clipping



Features:

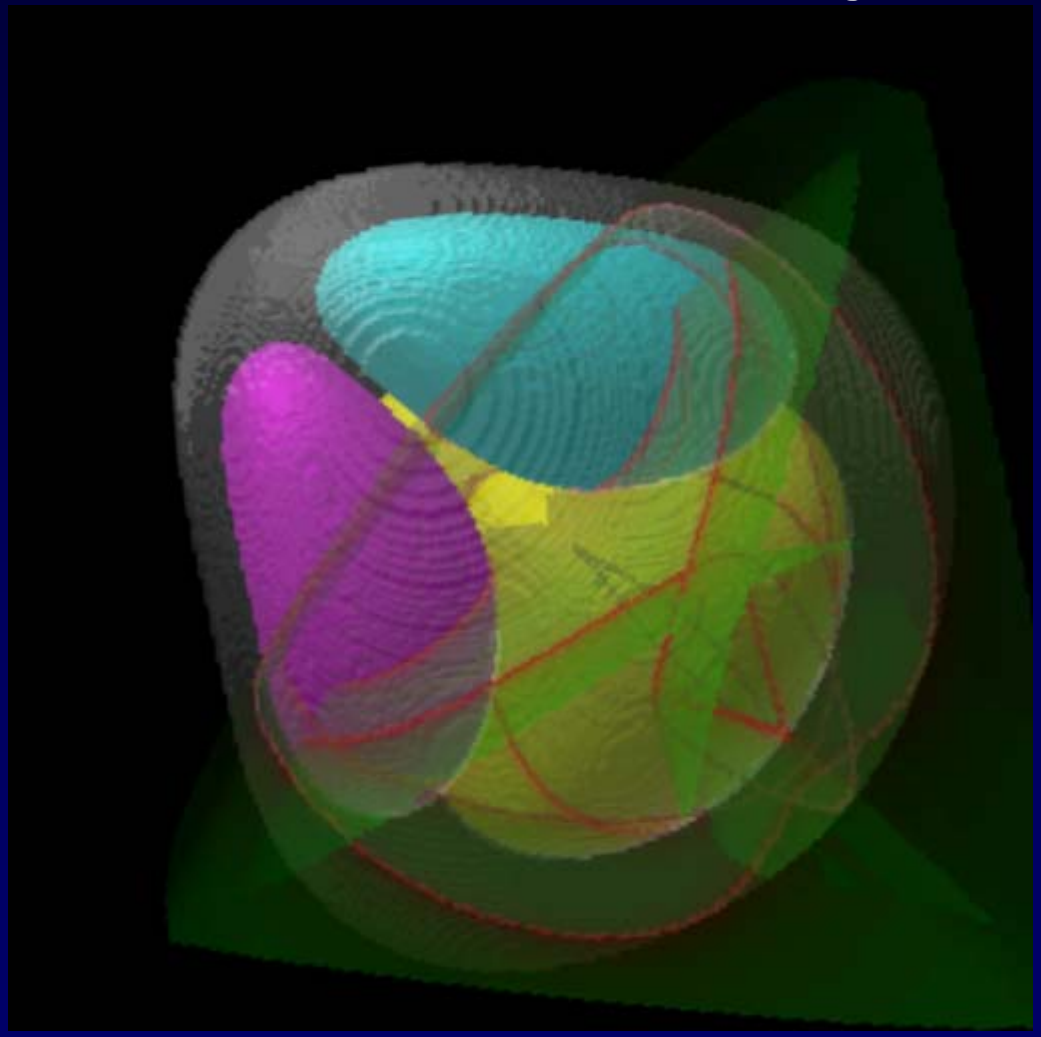
- free space leaping,free clipping planes

Quantized Gradients ⇒ LUT for shading

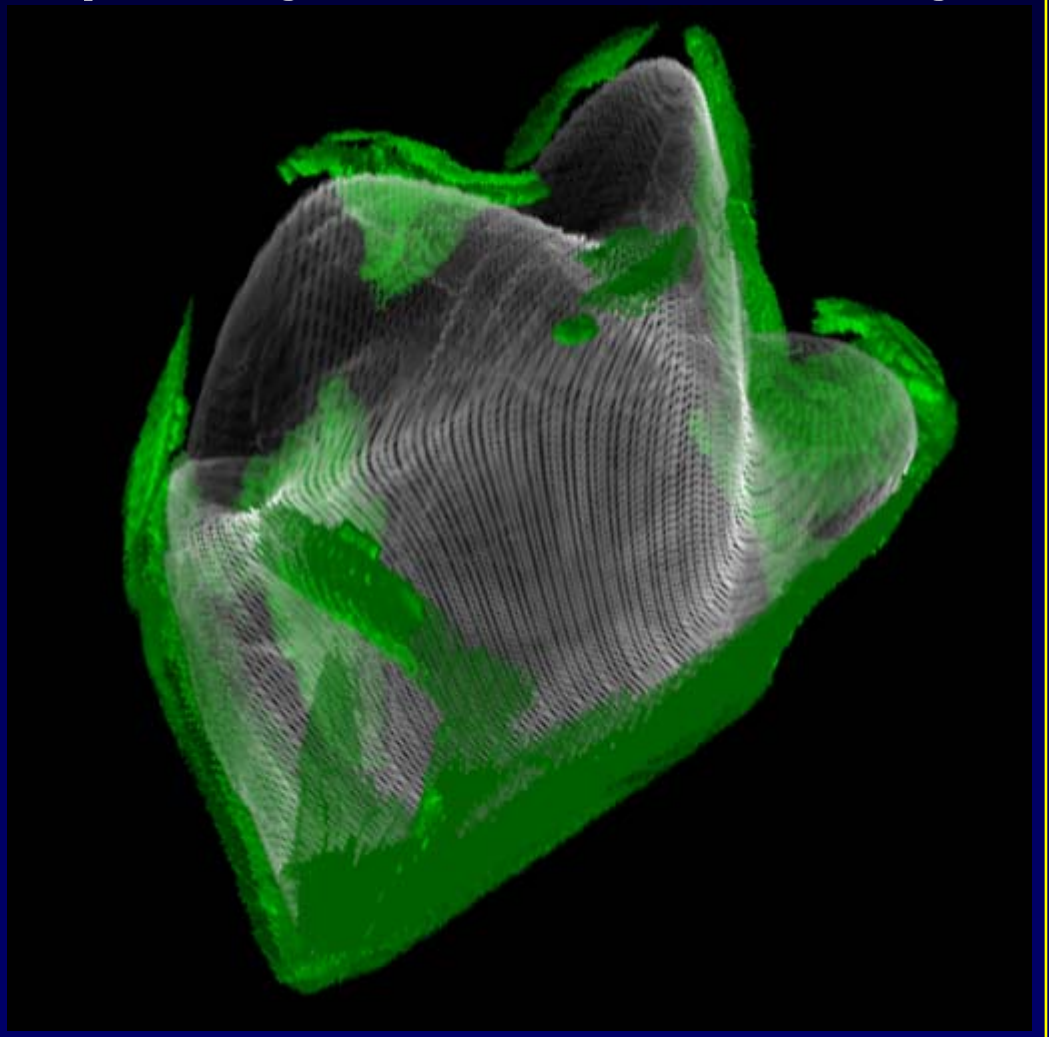
Java-Impl. on PC (AMD Athlon 600)

Further Extensions

Color ≈ basin vicinity



Opacity ≈ basin vicinity



Live demo

by Lukas Mroz

Summary

- New approach to fuse different volume rendering techniques
- Two-level approach: rendering locally and globally in parallel
- Useful application: focus'n'context
- Interactive Implementation:
  - Reversed Storage Scheme
  - Shear-Warp Factorization, no interpolation
  - Quantized Gradients
  - ~256^3 $\Leftrightarrow$ ~170ms (600MHz PC)

Conclusions

- Focus’n’context:
  important for scientific visualization!
- DVR good for low-frequency objects, 3D,
  but: over-loaded images
- MIP good for complex objects & context,
  but: flat without anims.
- Two-level Volume Rendering: arbitrary local rendering (nonphotorealistic rend.)
- No optimal approach per se,
  interaction very important for visualization

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The end