Two-level Volume Rendering – fusing MIP and DVR

Helwig Hauser
and Lukas Mroz
(VRVis Research Center)

Gian-Italo Bischi
(University of Urbino)

M. Eduard Gröller
(Vienna Univ. of Techn.)
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 ⇒ easy-to-control transparency
- concentrates on values of importance (proper transfer function needed)
DVR vs. 2lVR

All: DVR

Skull, skin: MIP;
Vessels: DVR
DVR vs. 2IVR

All: DVR

Bones, skin: MIP;
Arteries: 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 ⇒ 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
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 $\Rightarrow$ LUT for shading

Java-Impl. on PC (AMD Athlon 600)
Further Extensions

Color $\approx$ basin vicinity

Opacity $\approx$ 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
  ◆ $\sim256^3 \Leftrightarrow \sim170\text{ms (600MHz PC)}$
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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