A Medical Volume Visualization System supporting Head-Tracked Stereoscopic Viewing and Direct 3D Interaction

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Introduction

We have developed an experimental medical volume visualization system supporting head-tracked stereoscopic viewing registered with direct 3D-interaction. We aim to assess the suitability of these techniques for surgical planning tasks in real medical settings.

In particular, vascular surgeons examining the distal site of the aneurismatic sack are assisted by visualizing the artery aneurism in depth. A better understanding of such complex spatial structures is achieved by incorporating motion parallax and stereoscopic cues to depth perception not available from static images. Our display when positioned as a surgical table provides the impression of looking down at the patient in a naturalistic way. With simple head motions, good positions for observing the pathology are quickly established.

2. Methods

Direct volume visualization is a rendering technique which does not require the construction of intermediate geometric representations and has the advantage of supporting the representation in a single image of the full data set using semitransparent mapping. For this reason, direct volume rendering techniques based on "ray casting" [1], "splatting" [2], or "forward projection" [3] are increasingly being used for medical data.

For interactive performance we have chosen to directly render the volumes via back-to-front volumes-slices composition, exploiting texture mapping and alpha-blending on high-end graphics accelerators [4]. This type of rendering technique has been recently introduced to the graphics community by Wilson et al. [5], Cullip e Neumann [6], Cabral et al. [7], and Van Gelder et al. [8].

Our implementation in standard OpenGL supports interactive classification mapping, where body structures are highlighted by varying opacity and color look-up tables (Drebin/Levoy classifications, Phong shading). Classification operations are done in a preprocessing step by using our VOLVIZ library [9], which also provides the system with support for reading DICOM data files. This makes it possible to directly download and display volumes acquired using a DICOM- compliant scanning device.

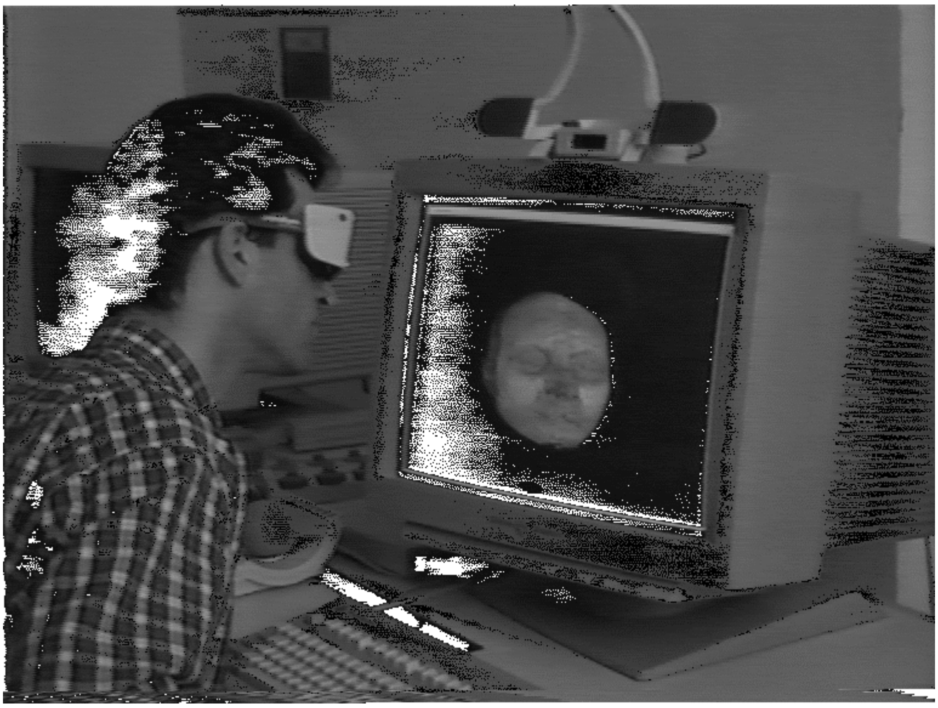

Figure 1. Interactive viewing of a volume-rendered head

The full potential of real-time volume rendering is exploited when allowing users to view and interact with the volume in a natural way. In our system, a six-degree-of-freedom head-tracker measures head motion then appropriate stereoscopic images are dynamically generated for shutter-glass 3D-viewing. With this technique, it is not necessary for the viewer to resort to manual commands to change the viewing position, leaving both hands free to interact with the volume. Small head motions and stereo viewing enhance the perception of subtle shape details. Co-registrating physical and virtual spaces means volumes appear at fixed physical positions and permits direct interaction via a 3D-pointing device.

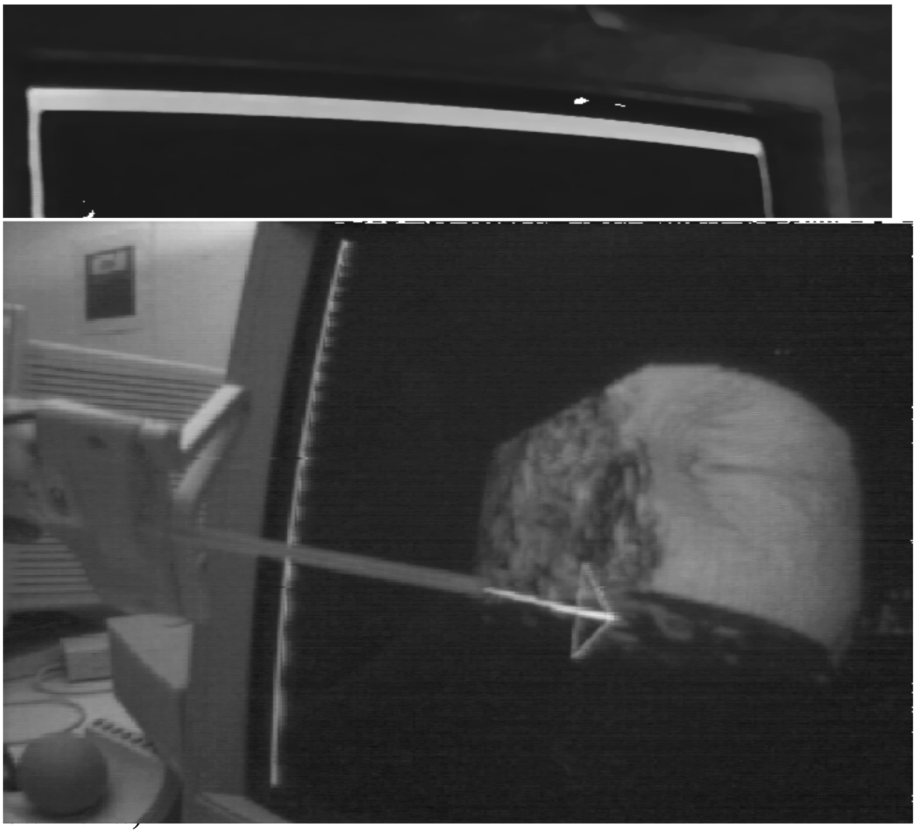

Figure 3 Interactive volume cutting

Cutting planes and common 2D visualization techniques are also available. Direct 3D input is used for 3D interaction tasks. For example, it is possible to interactively cut the volume to analyze its interior by directly positioning cutting planes with the 3D mouse.

Results

The system was tested on a SGI Infinity Reality, with CrystalEyes shutter-glasses and Logitech 3D-trackers. This permits interactive (>10 frames-per-second) work with a 128x128x128 dataset. This system should work with little modification on any high-end OpenGL machine.

Conclusions

We described a medical volume interactive stereoscopic visualization system, inherently portable (written in OpenGL without vendor-specific extensions) and capable, on high-end workstations, of interactive speeds. Expansion of PC and video game markets means that good texture mapping hardware accelerators may soon make these methods affordable in real medical settings

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