Emissive Clipping Planes for Volume Rendering

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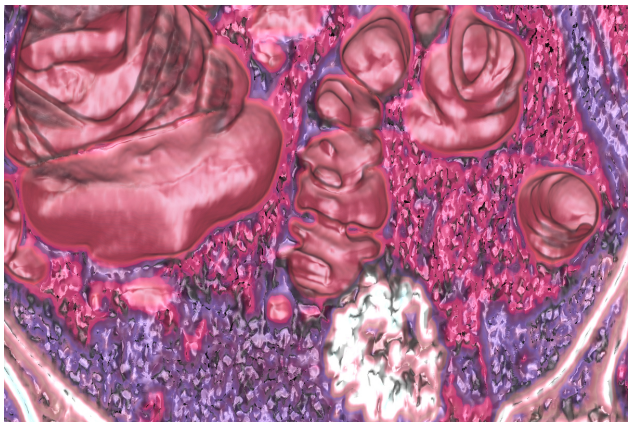

Figure 1. The inner walls of the colon are easy to see. On the right the colon extends into the volume. While the walls are clear, the clip plane itself makes the image too distracting to be useful.

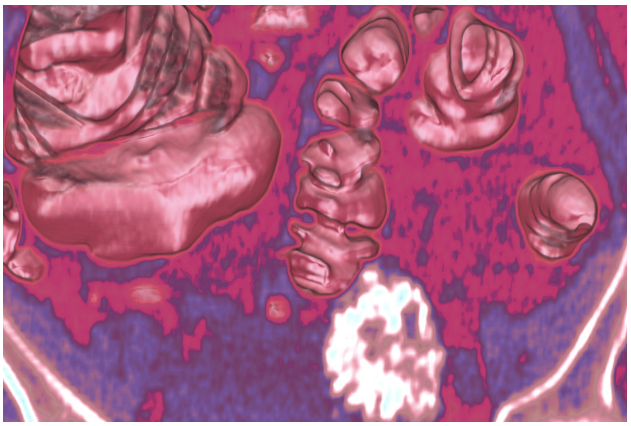

Figure 2. The emissive clip plane reveals muscle (blue), fatty tissue (dull red), the hip bone in the lower left and a fibrous mass in the lower right. The resulting image shows both the clip plane and the colon walls.

Introduction

Volume rendering has become an essential tool in medical imaging. Lighting allows the doctor to understand the shape of the organs and blood vessels and spot abnormalities. Cutting through the volume allows one to see the tissues in relation to one another. However, when homogeneous materials are cut and illuminated, the result is speckled with bright and dark splotches. By rendering a thin slice with only emissive illumination, the tissue in the clip plane is revealed as well as the structure of the organs below. The result is a useful diagnostic image.

In volume data, greater differences in tissue density yield larger estimated gradients. By making the less dense tissue transparent we display the surfaces that are implicitly defined in the data. By using the gradients as surface normals in the Blinn-Phong illumination model, the surfaces facing the light get brighter; the back facing surfaces do not contribute and create dark areas, which are only exposed when clipping. These dark areas are replaced with material color in the emissive clip plane.

In homogeneous material, neighboring voxels have similar values. However, there is some noise due to formations smaller than the voxel spacing. Gradients estimated between these voxels are small and have random orientations. When these gradients are used for lighting, the result is extremely distracting. Kniss recognized this problem and proposed using an alternate illumination model for low gradient samples. Our solution is less general, but works with existing special purpose hardware[Wu] and maintains interactive frame rates. It is also applicable to volume rendering algorithms using precomputed gradients on commodity graphics hardware such as the ATI Radeon or NVIDIA GeForce.

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Images rendered with the TeraRecon VolumePro 1000 [Wu].

Exposition

In our implementation, we render two times. First, we render the volume behind the clip plane with lighting turned on. Second, we render the thin emissive slice with no diffuse or specular reflection and maximum emissive illumination. The additional render is so thin that it does not decrease performance.

This technique works best when there is no partially translucent homogeneous material. In medical imaging is to common to render the less dense material as transparent and transition relatively quickly to totally opaque.

We did consider and implement gradient modification at the clip surface. This will solve the problems and does help understand the orientation of the cut. However, it does not help see the material in the plane, which is the goal in our case. It is an added computational expense with no gain in image quality.

The emissive clip plane provides a pragmatic solution for two illumination problems when cutting through a volume: random lighting in homogeneous materials and dark areas caused by back facing surfaces. The result is an image that both shows a clean cut surface and the illuminated structures below it.

References

KNISS, J., PREMOZE, S., HANSEN, C., EBERT, D. 2002. Interactive translucent volume rendering and procedural modeling. In *Proceedings of the conference on Visualization '02*, IEEE Press.

WU, Y., BHATIA, V., LAUER, H., SEILER, L. 2003. Shear-image ray casting volume rendering. In *Proceedings of the 2003 symposium on Interactive 3D graphics*, ACM Press.