Juan Felipe Cerón Uribe
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Scientific Computing and Visualization

Two-Level Volume Rendering

Paper Review

This document is a paper review on:

Hauser, H., L. Mroz, G. Italo Bischi, and M.e. Groller. "Two-Level Volume Rendering". *IEEE Transactions on Visualization and Computer Graphics* 7.3 (2001): 242-52. Web.

Introduction

This paper proposes a volume rendering methodology that facilitates the user's discernment of a 3D scene's individual objects. It does so by enabling the use of different rendering techniques for different subsets of the scene dataset, seeing as these techniques each have specific strengths and weaknesses in representing different kinds of data.

In this technique, for each pixel in the image we investigate a ray traversing the volume data from a background plane to the viewing point on two parallel tracks:

1. As long as the ray traverses one individual object within the data, rendering is performed on a local track to compute an object representative associated to the segment.
2. Where object classification changes, update steps in a global rendering track are performed, usually through standard DVR compositing.

Rendering Techniques Review

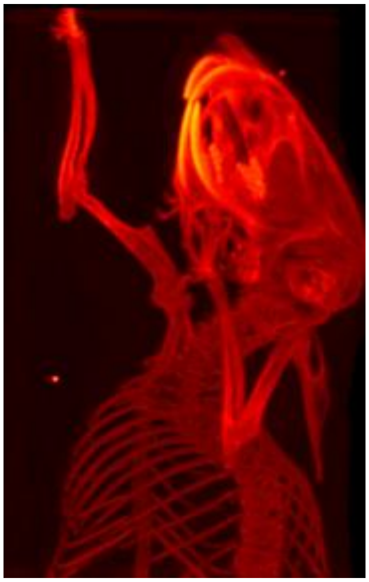
In order to give context to the following discussion we include a short review of three commonly used rendering techniques:

Direct volume rendering: A rendering technique in which every sample value is mapped to opacity and color.

- Designing a transfer function can be a very difficult task; it is a field of research on it's own.
- Producing useful images is difficult when there is no correspondence between differences in data values and discrimination of objects.

Maximum intensity projection: Only the voxels with maximum intensity along each ray are projected.

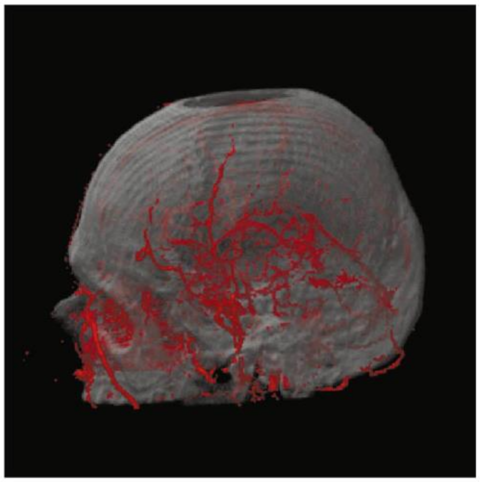
- Imporant information hidden due to viewing angle is minimal.
- Doesn't provide a good sense of depth. This is very evident on the following example from [2]; the MIP-rendered densities along a mouse's volume:

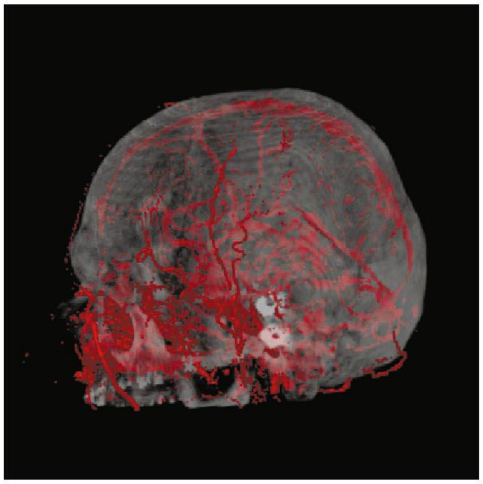


Positive aspects

Firstly, Two-Level Volume Rendering allows scientists to take advantage of the characteristics of several rendering techniques. For instance, DVR and surface-based techniques communicate 3D shape very well, but may overload an image with context making complex objects difficult to tell apart.

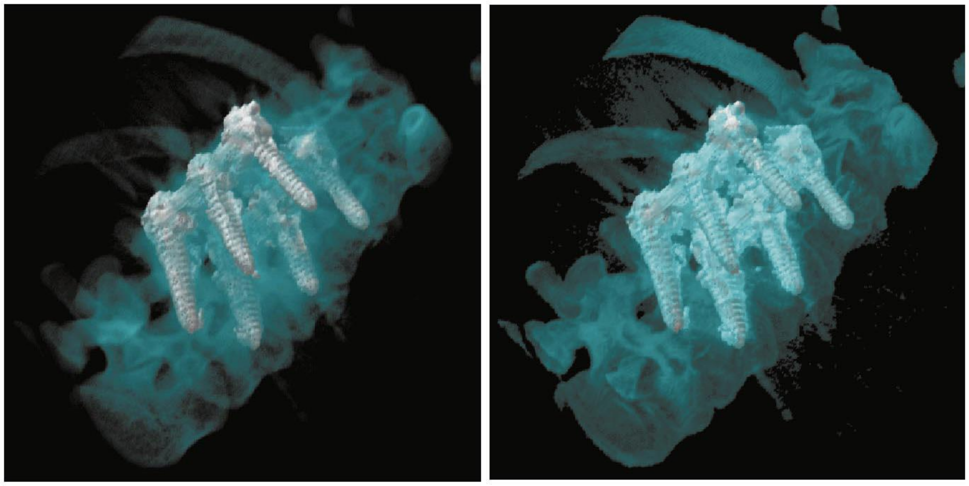
Of the following two images, the one on the left was rendered using standard DVR. The one on the right was rendered through Two-Level Volume Rendering: the shape of the skull using DVR and the blood vessels using MIP. Images taken from [1].





The blood vessels look very blurry in the first (in reality they are sharply defined objects), especially those on the back of the volume. On the second they are very sharply defined, and we can even see those behind the skull, while a DVR-rendered skull provides geometric context. Notice how the flatness of the MIP render is perfectly complemented by this context; the vessels don't look flat at all (even though rendered through MIP)!

Another positive aspect of this new technique is that it strongly supports "Focus+Context" style applications. The previous images are an example of one such application; the vessels are focused on while the skull provides spatial context. Have a look at one more example of this, taken from [1]:



Here, MIP was used for the context as it features quite uniform transparency, allowing us to focus on the object in the middle. Observe how the object is only partially visible in the first render. The authors of [1] provide the following table describing how some techniques may be useful as context or focus:

TABLE 1
F+C Configuration for Two-Level Volume Rendering

	focus	context
DVR	± rather opaque, surface-like	± rather transparent, gel-like
MIP	+ complex focus, high contrast	+ very uniform transparency
surfaces	+ rather opaque	+ semi-transparent
x-ray	−	± inner context
NPR	± only as add-on	+ sparse contours

Negative aspects

The first negative aspect of this paper is that it assumes a dataset which has already been segmented into individual objects. This classification task can be extremely complex to solve, as well as computationally expensive, and without such a segmentation the described technique is virtually useless.

On the other hand, the authors did not provide data comparing the computational cost of the described technique to that of standard techniques. They only provide their own rendering times. Computational expenses are a natural concern for visualization professionals, as a rendering technique is useless if it is unviable. The provided rendering times [1]:

TABLE 2
Rendering Times

figure	*volume size*	*rendering time*
3(a)	$256 * 256 * 100$	0.09 s
8(b)	$202 * 152 * 255$	0.18 s
8(c)	$256 * 256 * 241$	0.17 s
9(c)	$256 * 256 * 256$	0.17 s

References

1. Hauser, H., L. Mroz, G. Italo Bischi, and M.e. Groller. "Two-Level Volume Rendering". *IEEE Transactions on Visualization and Computer Graphics* 7.3 (2001): 242-52. Web.
2. “Maximum intensity Projection”. *Wikipedia* (2017). Web.