Advanced Medical Volume Rendering and Segmentation on the GPU

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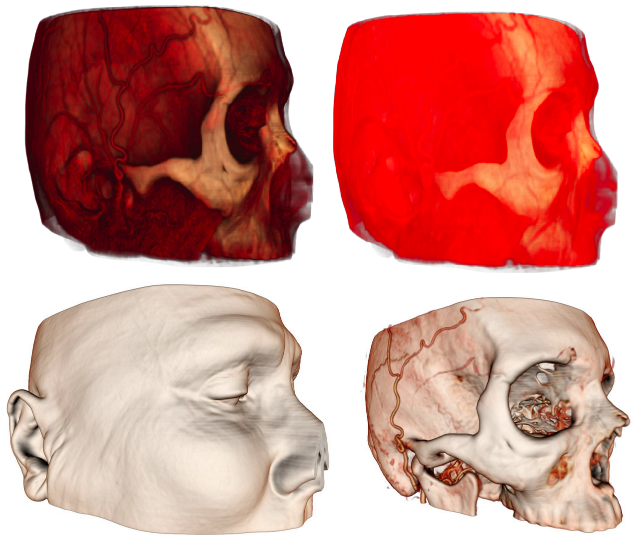

Figure 1: *Top Left: our GPU volumetric ambient occlusion algorithm visualizing a 512^3 CT data set at 30 fps. Top Right: the same data set rendered with the same transfer function but without ambient occlusion. Ambient occlusion provides important perceptual cues about the structure and topology of the data set. In contrast to previous GPU algorithms, our algorithm supports interactive transfer function editing without requiring any costly preprocessing or recomputation of auxiliary data structures. Bottom: our GPU hierarchical volumetric ray casting algorithm visualizing two different isosurfaces of the same data set at 130 fps – $15\times$ faster than unoptimized GPU volumetric ray casting with no reduction in rendering quality.*

Volumetric visualization plays an important role in many image-guided surgical procedures, and is an important investigative tool in diagnostic medicine. Identifying the distinct regions in volumetric images – a task known as *segmentation* – is also an important diagnostic tool.

As a physician interactively explores and takes measurements of a volumetric medical data set, the tasks of visualization and segmentation complement each other: an initial visualization can help a physician to roughly identify regions of interest within the data set; interactive segmentation methods can precisely quantify those regions with minimal user interaction; and those segmented regions can inform the interactive visualization and subsequent exploration.

We present three novel GPU algorithms that improve the quality and interactivity of the work-flow described above:

1. A volumetric ambient occlusion algorithm that improves image quality by providing important perceptual cues about the structure and topology of the data set (Figure 1). In contrast to previous algorithms [Ropinski et al. 2008], our algorithm supports interactive transfer function editing without requiring any costly preprocessing or recompututation of auxiliary data structures.

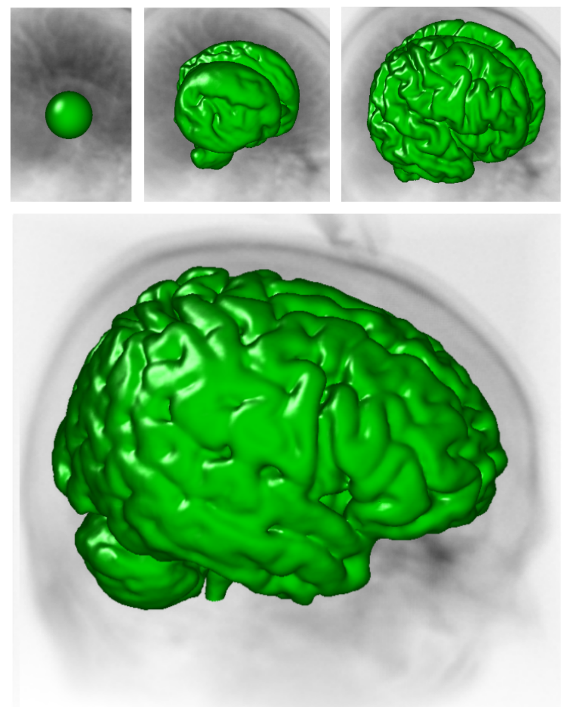

Figure 2: *Our GPU level set segmentation algorithm interactively segmenting the brain matter in a noisy (signal-to-noise ratio of 11) 256^3 MRI in 7 seconds – $14\times$ faster than previous GPU algorithms with no reduction in accuracy.*

2. A hierarchical volumetric ray casting algorithm that is $15\times$ faster than unoptimized volume ray casting without affecting image quality (Figure 1).

3. A work-efficient level set segmentation algorithm that is $14\times$ faster than previous algorithms [Lefohn et al. 2004] and improves the asymptotic step-completexy of previous algorithms [Jeong et al. 2009; Lefohn et al. 2004] without affecting segmentation accuracy.

For a more comprehensive description of these algorithms we refer the reader to our recent work [Roberts et al. 2010; Penner 2009; Penner and Mitchell 2008].

References

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