Enhancement Techniques for Human Anatomy Visualization

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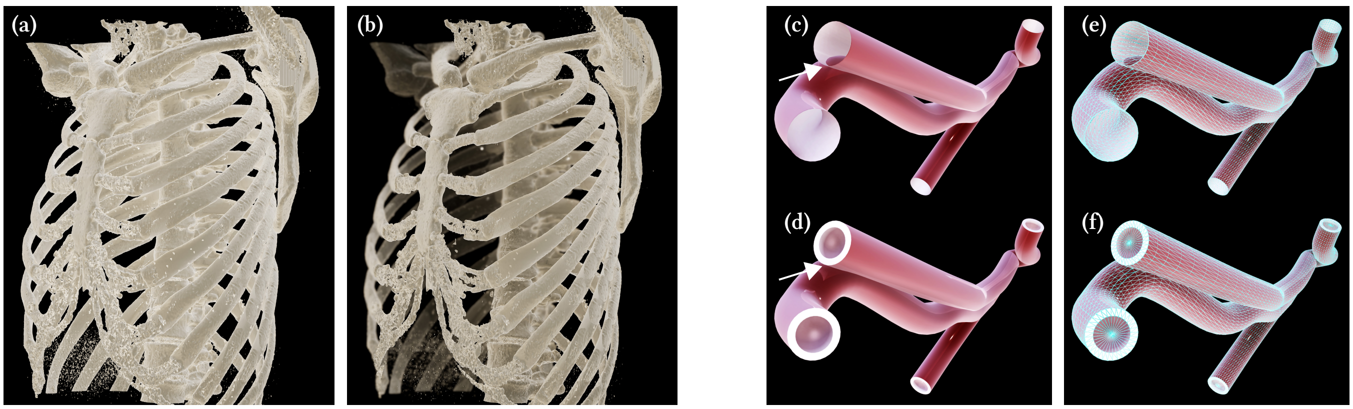

Figure 1: (a) Original rendering result. (b) Screen Space Ambient Occlusion, Depth of Field, and Depth Cueing have been added to (a). (c) Original polygonal tubes. (d) (c) with "caps" seems to thick and hollow tubes. (e),(f) Wireframe of (c),(d) respectively.

ABSTRACT

We propose two simple and efficient visualization techniques for assisting understanding of complex three-dimensional structures like human anatomy: (1) applying Screen Space Ambient Occlusion (SSAO), Depth of Field (DoF), and Depth Cueing (DC) to an original rendering result image in real-time, and (2) adding "caps" to thin polygonal tube structures which results in pseudo-thick, hollow structures with a small amount of additional polygons.

CCS CONCEPTS

• **Computing methodologies** → *Visibility*;

KEYWORDS

Visualization, Medical, Anatomy, Blood Vessel

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1 INTRODUCTION

3D reconstruction of human anatomy from medical images like CT or MRI is quite common, but the visualization method is often still very old. We introduce two simple techniques to enhance visualization of human anatomy: one is post processing for rendering, and another is a simple trick for geometry processing.

2 METHOD

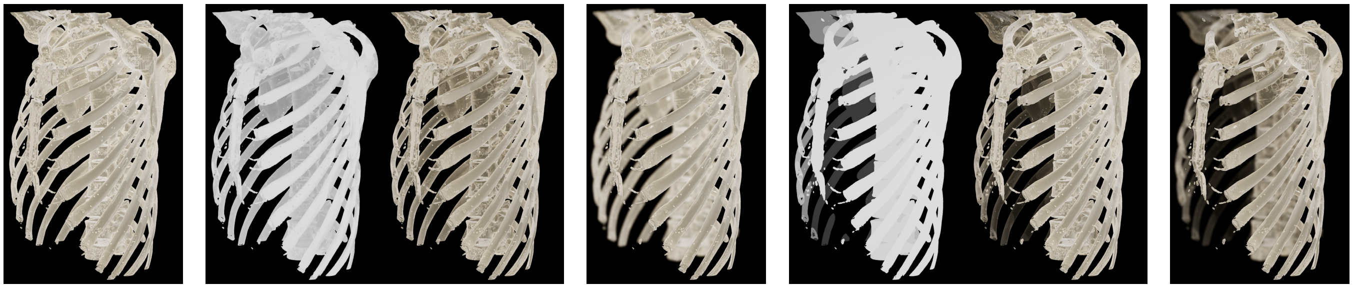
2.1 Applying Post Processing in Real-Time

Human anatomy is so complex that just visualizing it in traditional ways is insufficient for easy understanding like Figure 1(a).

Three post process effects - SSAO [Aalund and Bærentzen 2013], DoF [Demers 2004] and DC - are all available in real-time, at least with some built-in game engines. Each effect uses screen space normal vectors and / or depth values, so compatible with deferred shading, but also applicable in forward shading or volume rendering if the vectors and values are stored. SSAO emphasizes occluded, sheltered areas, while DoF and DC emphasize depth of visible objects. So the combination of the effects is helpful for understanding complicating 3D structures like human anatomy. See the results on Figure 1 (a), (b), and the step by step outputs on Figure 2.

2.2 Adding "Caps" to Thin Polygonal Tubes

There are a lot of tube-like branching structures inside our body, blood vessels and bronchi for example. One of the methods for representing such structures is extracting the central lines and radii at each vertex on the lines, and making polygonal tubes by extruding a base circle along the lines, like Figure 3(a)-(c). However, the generated tubes look strange because they have no thickness



(a) Original (b) SSAO (c) (a) + SSAO (d) (a) + DoF (e) DC (f) (a) + DC (g) (a) + SSAO + DoF+ DC

Figure 2: 3D reconstruction of a thoracic CT volume image using GPU-based marching cubes [Dyken and Ziegler 2010; Lorensen and Cline 1987].

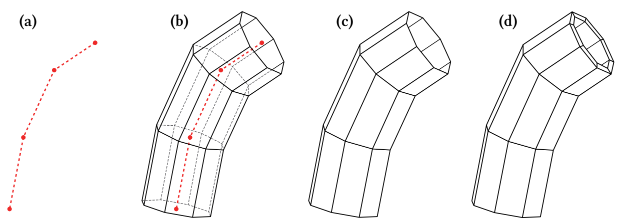


Figure 3: A polygonal tube generation by it's central lines and radii at each vertex.

like Figure 1(c). So polygons for thickness and inner walls like Figure 3(d) is often added, but this method causes a lot of new polygons especially when the central lines have many vertices despite most of the inner walls are not visible in many cases.

Our method adds "pseudo inner wall" polygons instead of inner wall polygons like Figure 4(b). The "thickness" polygons and the "pseudo inner wall" polygons result in a "cap" on the tube. The vertices on the border of outer walls, thickness, and pseudo inner walls have been separated. Each vertex has a different normal vector like Figure 4(c). Reversing the normal vectors of thickness polygons like the green vectors on Figure 4(c) makes the cross section look like inner parts if we apply two-sided material to the tube.

Normal vectors of the pseudo inner wall polygons are the most important trick of our method. The inner direction vector perpendicular to the cap has been applied as a normal vector at the central tip vertex, and the direction vector aiming from the central tip to each border vertex at each vertex like Figure 4. This mimics a reversed dented hemisphere, and the shaded result looks like as if the tube has inner walls like Figure 4(d) and 1(d). This method not only saves the number of polygons to add in comparison to making actual inner walls, but also contributes to hide the penetration of objects into the tubes. See the white arrow at Figure 1(c) and (d). This technique has been used in our real-time virtual brain aneurysm clipping surgery software project [Seo et al. 2018].

3 RESULT

We have tested both methods on Microsoft® Windows® 10 PC with CPU Intel® Core™ i7-7700K 4.2GHz, Memory 64G, and GPU NVIDIA® GeForce® GTX 1080Ti. We have implemented GPU-based marching cubes method based on [Dyken and Ziegler 2010] and integrated it into Epic Games Unreal Engine 4.16. The volume image

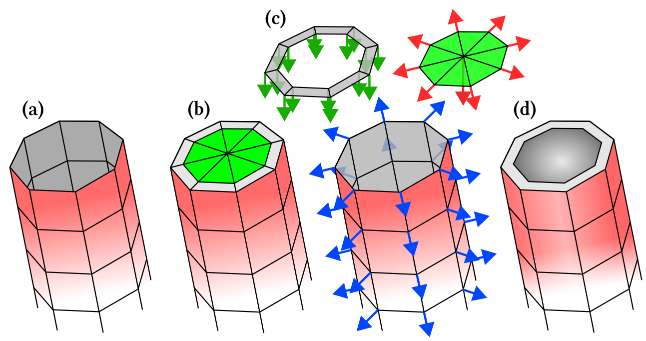


Figure 4: (a) Original polygonal tubes. (b) Add "cap" to (a). (c) Normal vectors on each vertex. (d) The shaded result. See also Figure 1(c) and (d).

used consists of 256 x 256 x 463 voxels, and the generated object shown in Figure 1 and 2 has about 1.4 millions triangle polygons.

The frame per second (FPS) of Figure 1 and 2 was about 63 FPS without any post process effect, while 60 FPS with all SSAO, DoF, and DC effects. We think this is fast enough. Figure 1(c) and (d) are the rendered result of Figure 4(a) and (d) by Unreal Engine 4.16.

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