Mystery Dataset

Scientific Visualization & Virtual Reality

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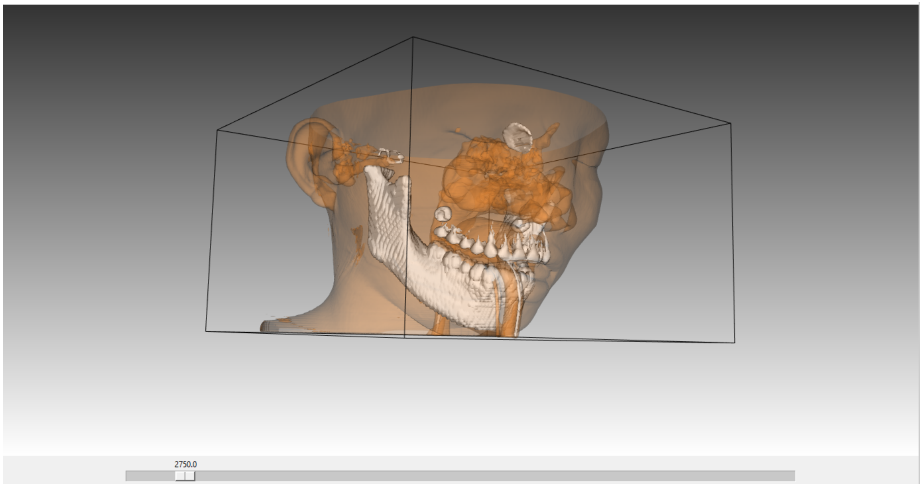

Figure 1: Visualization of the binary image dataset

1 Introduction

In this hypothetical challenge we were given a binary image dataset[1] of unknown format from a CT scan. The human body in the CT scan is taken from a crime scene, yet the cause of death of the person in question is unknown. It is requested of us to investigate the digital body and determine the cause of death.

2 Approach

2.1 Datastructure

Before a visualization could be made it was necessary to determine the structure of the dataset. Each file was 131,072 bytes and as CT scanners produce stacks of images of 256×256 pixels, each pixel is 2 bytes or 16 bits. The other possibility of images of 512×512 pixels would result in 4 bit pixels which would only give us 16 possible scalar values per pixel. The latter is not a common nor a useful setting for a CT scanner.

To determine whether the data was stored Big Endian or Little Endian, a first visualization was made using Big Endian as default. This resulted in a chaotic picture and changing to Little Endian produced the expected humanoid structure.

2.2 Visualization

This section describes the classes that are used from the visualization tool kit (VTK) [1] to visualize the data and determine the cause of death.

The first step is is to create a renderer and a GUI environment which will render and show the data to the user and allow for interaction with the user. This is created using VTK's *vtkRenderer*, *vtkTkRenderWidget* and *Tkinter.Tk*. Next the actual data has to be processed. For this VTK's class *vtkVolume16Reader* is used, which allows the user to read 16 bit images. After setting the dimensionality, the slice spacing and the endianness of the data, the files are read and ready to be used as the input for the contour visualization.

The class *vtkContourFilter* is used to create an isosurface based on scalar values, after which *vtkPolyDataNormals* is called to produce normals for smooth surface shading. In order to render the data a data mapper is used (*vtkPolyDataMapper*). This proces is repeated twice, one time for the isosurface of the skin and one time for the isosurface that is created based on the scalar value selected by the user. This scalar value can be selected by the user by moving a slider at the bottom of the visualization. This interactivity is provided by the scale method of Tkinter. An outline is added to the visualization to shown the extent of the data.

For easy camera alignment, first the three *vtkActor* instances: outline, skin and contour, are positioned with their center on the focal point and facing the camera. The camera, created with the *vtkCamera* class is initiated under a small angle to achieve a proper view of the object of interest. It is than set as active camera in the *vtkRenderer* so it will be used and can be manipulated in the renderwindow.

[1]Data set can be downloaded from: `http://bit.ly/1yY43gn`

3 Findings

In Figure 1 the visualization of the binary image dataset is shown. To better visualize the anomalies in body, two different colours are used to show the different scalar values. In the visualization the skin and parts of the brain are always shown to provide a frame of reference. With the slider, visible at the bottom of the figure, the user can change the scalar value and thus interactively determine what other parts of the data are visualized.

As can be seen in figure 1, there is a disk stuck in the kids skull between the eyes. It has been there for a while since the skin has grown back. The disc seems to be approximately of the same density as the outer shell of the teeth, called enamel. Enamel densities range from 2.8 to 3.0 g/cm^3 [2] which corresponds to materials like glass (2.4 - 2.8 g/cm^3) aluminium (2.7 g/cm^3) [3] and industrial plastics (2.8 - 4 g/cm^3) [4]. However, we see no scattering effects as is common with metallic materials. The disc seems to be thinner in the center and thicker on the edges. The grating that is visible in the center of the disc is probably due to the algorithm and under sampling.

Furthermore, something uncommon about the jaw came forward when the range of scalar values in the dataset was determined. These values range from 0.0 to 36685.0, where this upperbound is really high. At values around 2750, as shown in the figure, only the jawbone, teeth and the disc are still visible. When moving the slider further to the right, the upper teeth disappear but the lower jaw and teeth remain visible until the determined maximum scalar value of 36685. Therefore, it seems that the jaw and the teeth are made of some material with a density far beyond the density of bone and probably beyond the density of osmium ($\approx 20g/cm^3$), the densest material on earth. More likely however, would be that there is some mistake in the scalar values of the data set, as most dentin structures disappear around the value 4000 (a density of $\approx 3.0g/cm^3$). The scalar values of the lower jaw data are approximately 10 times as high as those of the upper jaw. This can indicate that the data of the lower jaw was added to the original data set with a different scalar mapping, which raises the question of the validity of the data as a whole.

Moreover, it can be doubted if the person in question was really dead at the time of the CT scan since there is an air pipe going down the throat which would not be necessary in case of a deceased person.

References

[1] "Vtk documentation." [Online]. Available: http://www.vtk.org/documentation/

[2] S. Weidmann, "Variations of enamel density in sections of human teeth," *ScienceDirect*, 2004.

[3] "The engineering toolbox." [Online]. Available: http://www.engineeringtoolbox.com/density-solids-d_1265.html

[4] "Dotmar." [Online]. Available: http://www.dotmar.com.au/density.htm