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Data Visualization

Project 5

Introduction

Below are two datasets, ‘brain.vtk’ and ‘engine_256x256z128_uint8.raw.’ The former is dataset 1 and the latter is dataset 2 in the files. The first dataset is a CT scan of the upper portion of a human head and the second dataset is a CT scan of a two-cylinder engine. Further details about them will be elaborated on below. The format of the document is to first present the dataset then subsequently three visualizations that include Figures that contain screenshots of the visualizations within ParaView.

First Dataset: brain.vtk

The first dataset is a CT scan of the upper part of a human head, from the nose up to the top of the head. The dimensions of the file are 180x216x180 according to the information tab in ParaView. It was found from the GitHub link provided by the professor in the discussions. The link leads to a GitHub repo, ‘pyvista/vtk-data,’ which contains many different datasets. The one chosen for the first dataset is ‘brain.vtk,’ therefore it’s a VTK file. There doesn’t seem to be any alternate information regarding the dataset, however. Since the dataset is that of a human head, it seems related to the medical field. Due to there being a lack of detail about the file, no further inference about where the data may come from or what the intended purpose can be made.

The first visualization is a combination of volume rendering and clipping. The dataset originally includes what appears to be some bar above the person’s head. It’s unclear what the material is or the purpose, but it can get in the way of the visualization. Therefore, this piece has been clipped. It’s possible to see this bar above the person’s head in Figure 1. To clip it, the clip filter is used with the clip type of sphere. The reason that the sphere clip type is used is that it fit well around the person’s head and was able to remove the bar in a single clip compared to the plane clip type which seemed to require multiple clips to completely remove the bar.

In Figures 2 and 3 are images of the complete visualization after both clipping and using volume rendering. Initially, it wasn’t possible to see both the person’s skin and the brain at the same time. The trick was to alter the colors within the color map. By tinkering with the color map settings, it was possible to make the skin appear reddish and the brain within the skull appear bluish.

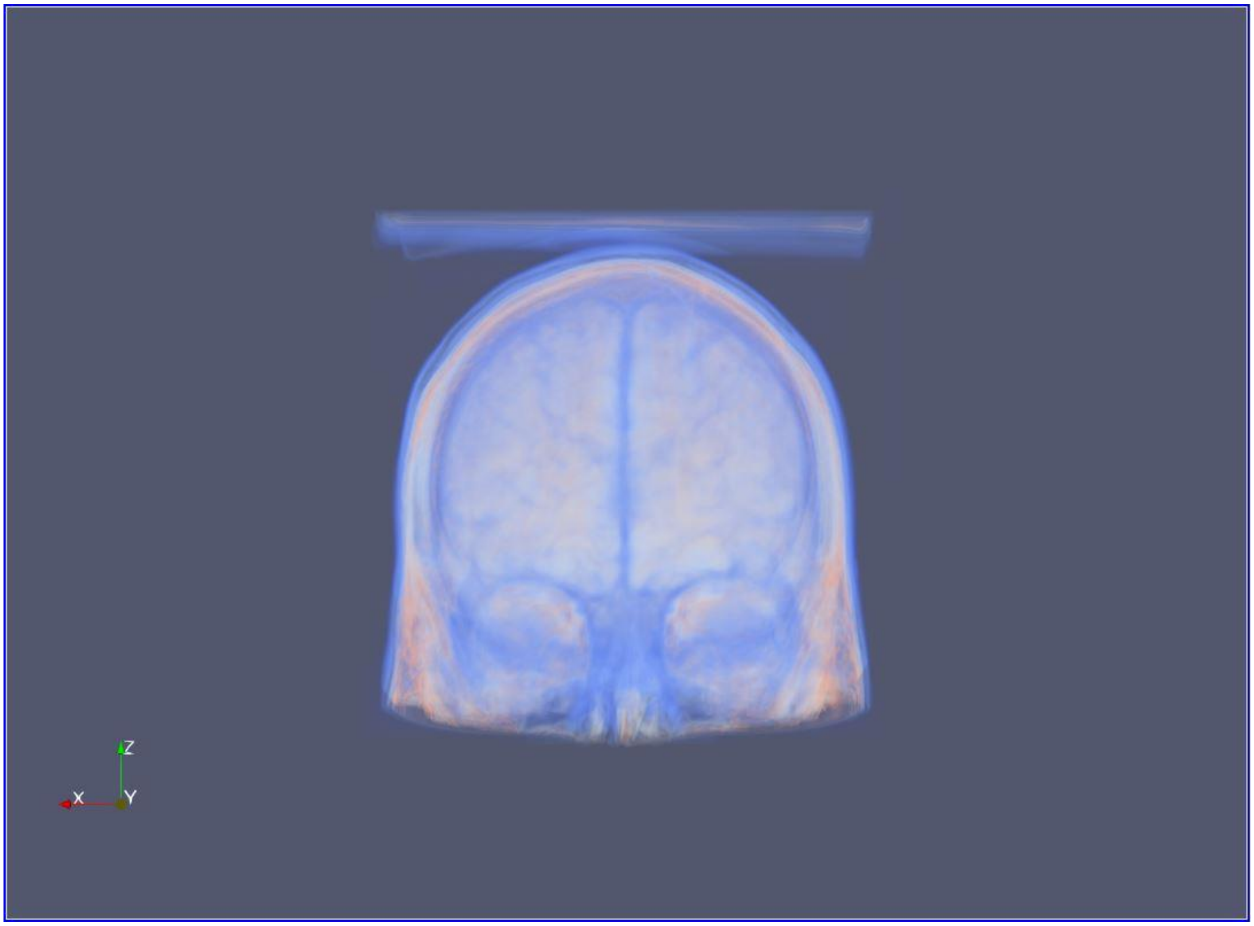

Figure 1 Image with bar above person’s head.

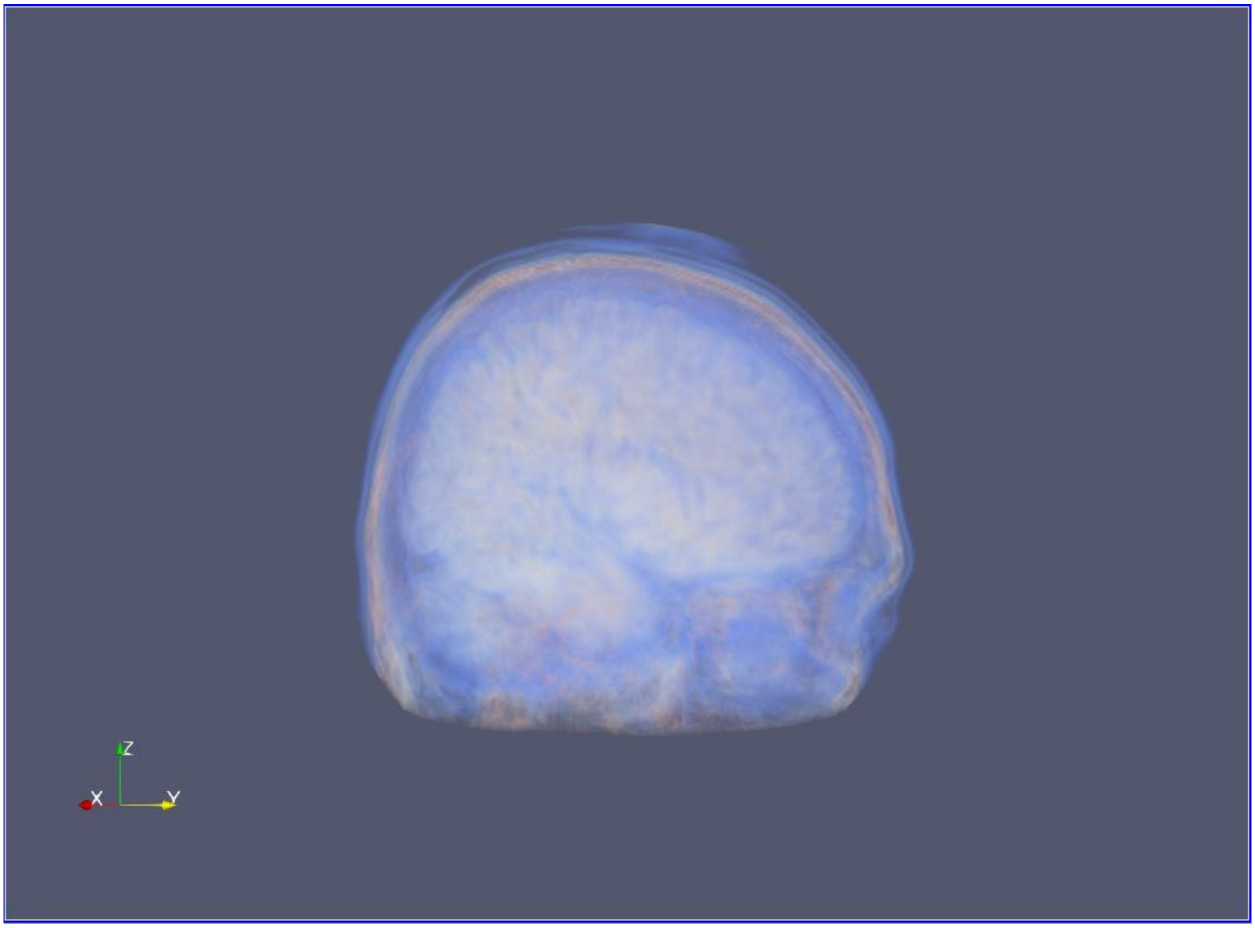

Figure 2 View of person's head from the right side after clipping and volume rendering.

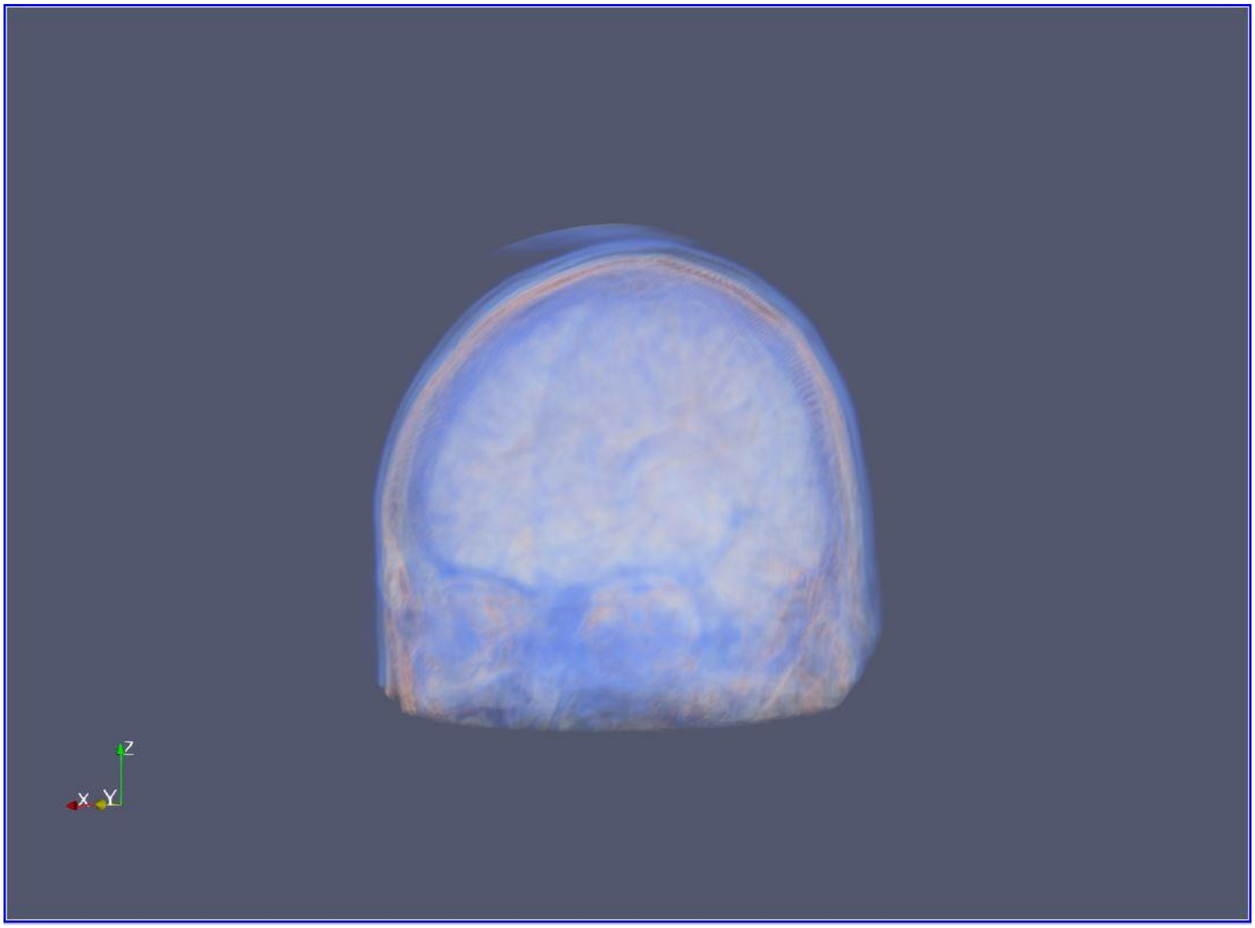

Figure 3 View of person's head from the front-left side after clipping and volume rendering.

The second visualization for the CT scan of the human head is an animation of the isosurface. The first step was to create an isosurface through the contour filter. This made it such that the CT scan appears as if there was an opaque layer of skin around it. Like in the previous visualization, there was an issue of a bar above the person's head, so another round of clipping was done to remove it. Interestingly, in this case a simple plane clip type was enough. Previously, when using a volume rendering, the bar was more difficult to remove. However, with the contour approach the clipping was comparatively easier to accomplish without requiring a sphere for clipping.

After creating the isosurface and clipping the data, the next part involves animating the data. When bringing in the Animation View, the option was chosen to let the isosurface change opacity over time. The total number of chosen frames is 50 to let it move slow enough so that the isosurface can be slowly seen from different angles. From the start of the animation to the middle it will phase from transparent to fully opaque, afterwards it will start to fade back to being transparent. At the same time, the camera will orbit around the isosurface. In Figures 4 it's possible to see the isosurface becoming opaquer as it gets closer to 20% through the animation. In Figure 5, at halfway through the animation the isosurface is roughly fully opaque. By this time, it’s also looking at the back of the head. It seemed more visually sensible to let the animation fade in and out one time within the animation cycle. It’s also possible to let it loop to see this process repeat.

There was the possibility to add color the isosurface, however it was not done for visualization reasons. It seems that when the opacity is changing regularly, it doesn’t help to have different color gradients to try and simultaneously perform the task of making the isosurface less opaque. After using different color patterns, it seems that the only noticeable change is that the isosurface becomes a different solid color. It seems that the default colors (i.e., Cool to Warm) do a satisfactory job and other colors seem to only have the extra task of changing which color the isosurface is (e.g., blue, green, or black).

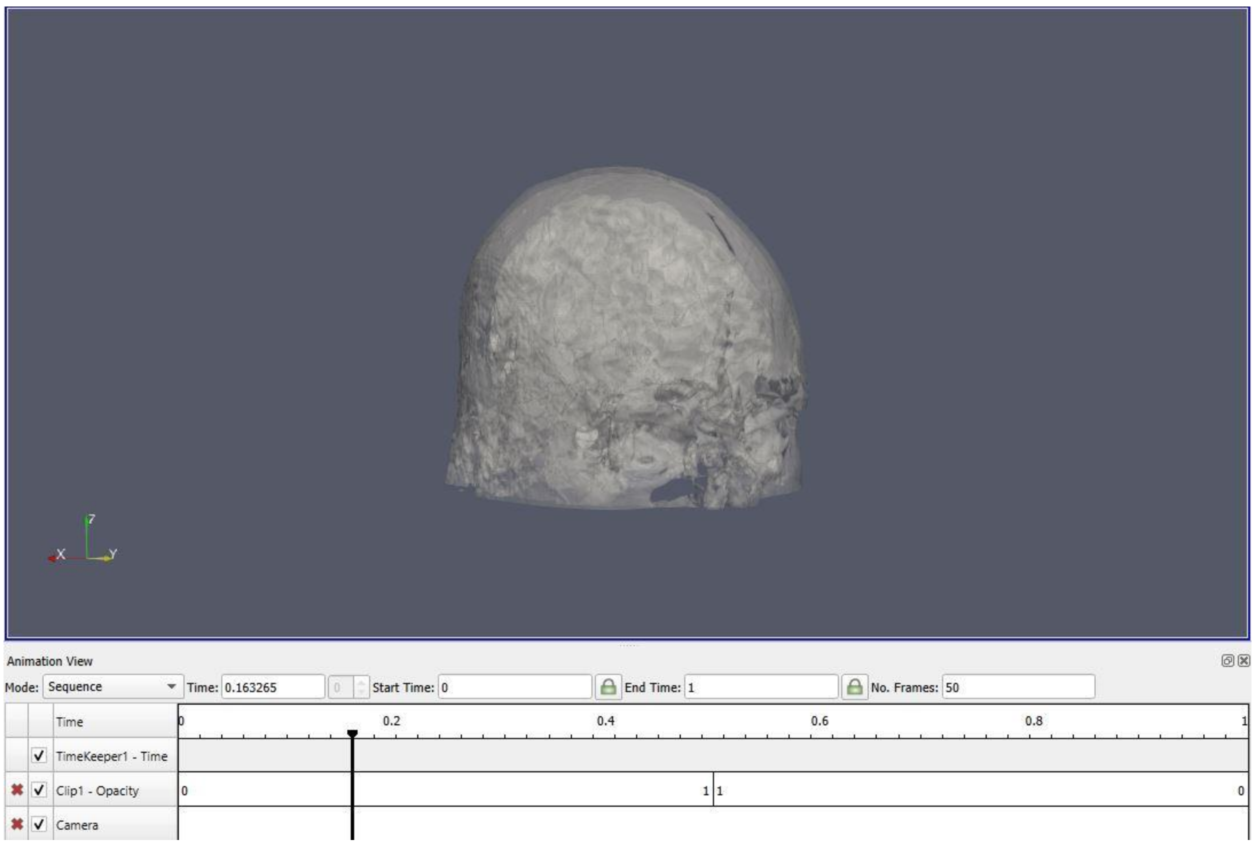

Figure 4 View of the orbiting animation at around 20% through the cycle. The isosurface is becoming opaquer.

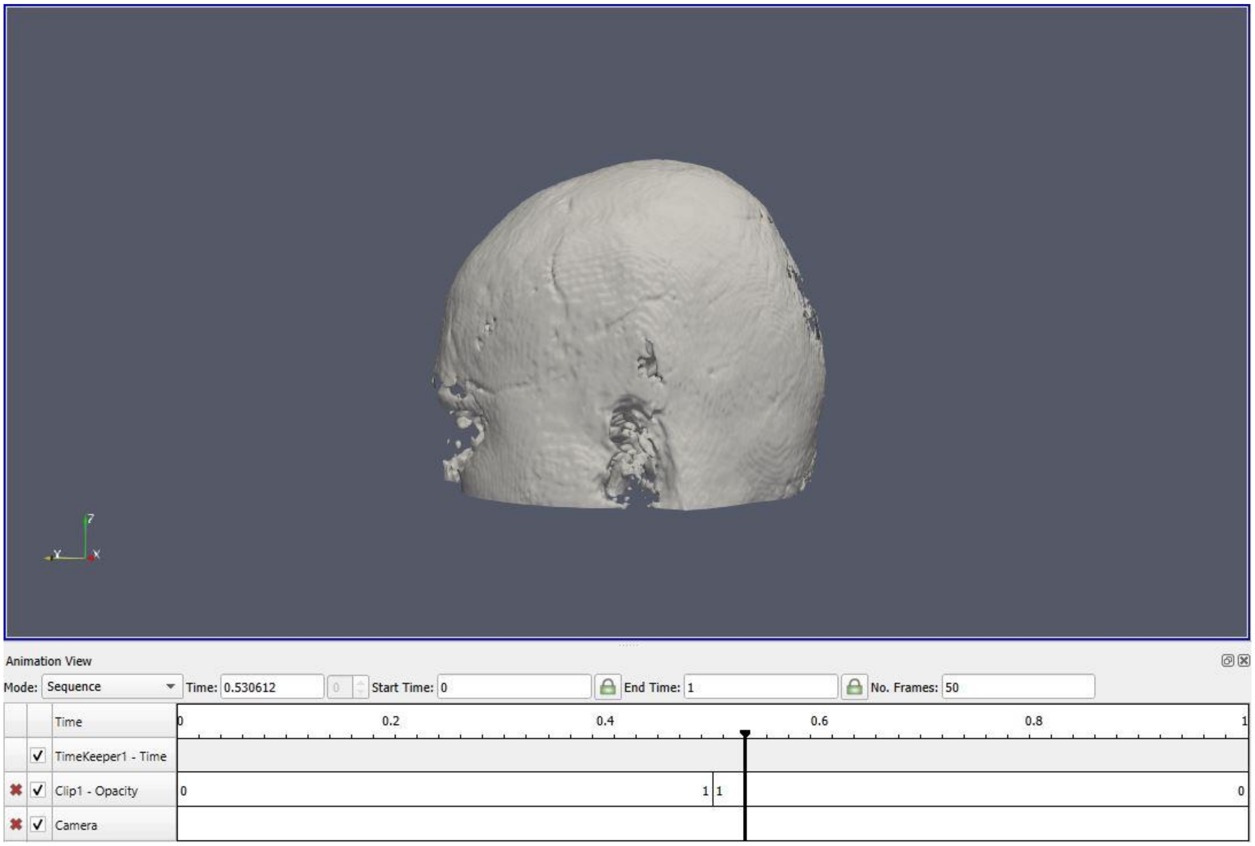

Figure 5 At around half-way through the animation, the isosurface has already become fully opaque and is becoming transparent. Furthermore, the camera has also orbited to face the back of the head.

The third visualization for the first dataset is inspired by a visualization seen on vtk.org's website called 'full_VisibleWoman.' This visualization likewise is that of a CT scan of a person's head and shows different dimensions at the same time. The dataset originally consists of slices that look like an MRI scan and so this visualization makes use of them. Each slice of the 'MRI scan' is just a single slice and so it's difficult to create a visualization that makes use of them in a meaningful way. The visualization seen in Figure 6 shows that there are three of these slices combined to show different cuts of the 3D dataset. There are slices on the right side of the person's head, in the back of the person's head, and in the center on the horizontal axis. The slices were chosen so that they represented a relatively interesting piece of the scans of the person's brain.

To better see the relative position of the person's head amidst the various slices from the CT scan, an isosurface is also included in the center of the visualization. Some clipping is also done using the plane method to remove the bar above the person's head which was also done in previous visualizations. A difference here is that an additional plane clipping was done to remove half of the isosurface to make visible the isosurface representation of the person's brain. Some opacity tuning was also set to 0.3 so that the isosurface would become see through. To make the contrast stronger between the transparent isosurface and the CT scan, the color was changed to Cool to Warm (extended) so that it'd be easier to differentiate between the two filters.

Lastly, the data axes grid of the original data are shown to help better see the boundaries of the data in the context of the slices and the isosurface.

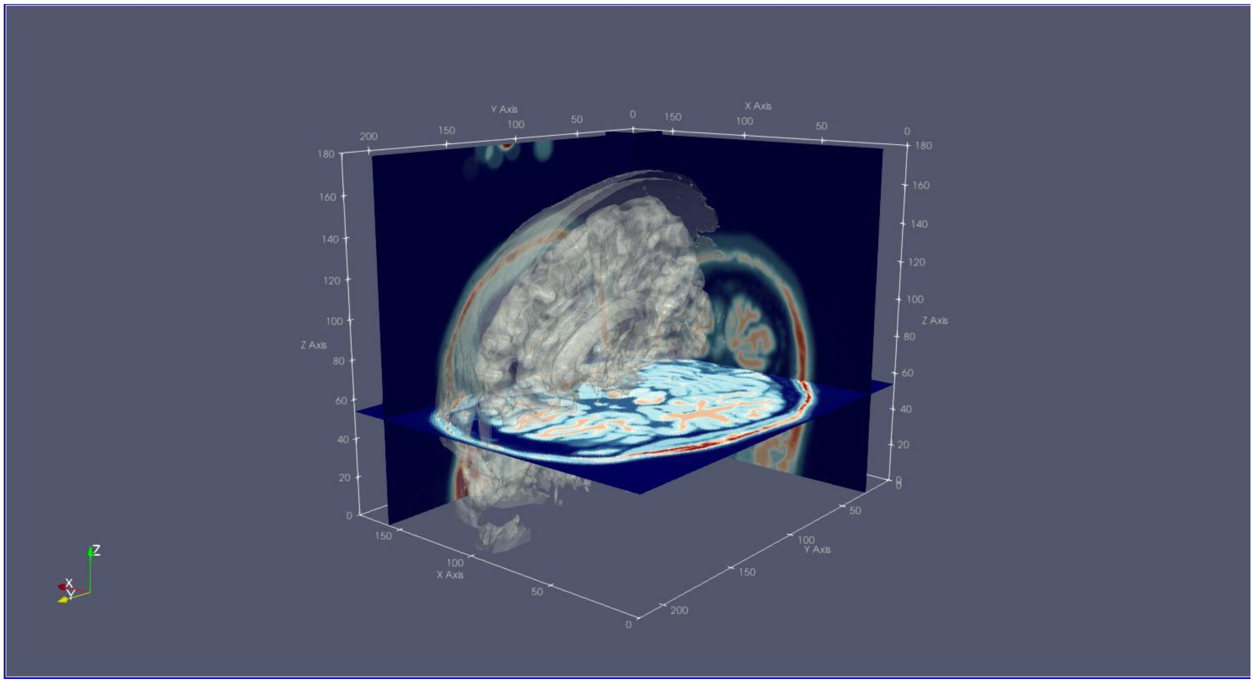

Figure 6 Showing different slices of the CT scan of the head. Half of a transparent isosurface is included along with data axes to show the relative position of the head with the different slices.

Second Dataset: engine_256x256z128_uint8.raw

The second dataset is called ‘engine_256x256z128_uint8.raw,’ and it comes from the website ‘klacansky.com.’ The website seems to be an academic’s personal website that contains publications and other information by an individual named Pavol Klacansky. The data was found after a classmate named Jason Thomen posted the link in the Module 12 Discussion under the title, ‘Anyeurism 3D Dataset.’ Initially, it was unclear about how to load the data into ParaView since it came under the extension ‘.raw.’ However, another classmate, Itsuki Ogihara, inquired about the process within the same discussion thread. Jason then made it clear that the steps involved loading the dataset with “Image Reader” in Paraview, then using the settings Data Scalar Type = unsigned char, Data Byte Order = LittleEndian, Data Extent = 0-255, 0-255, 0-127. The dataset itself is that of a CT scan of two cylinders of an engine block, according to the description on the website, with the dimensions are 256x256x128.

The first visualization can be seen below in Figure 7 and is a isosurface of the engine. To give more detail to the isosurface, the opacity is changed to 0.3 so that it’s possible to see inside the engine. The result is that the different cylinders within the engine and the various connections that they have also become visible. I myself am not an expert on engines so I can’t say with certainly what parts are what within the visualization itself. However, this transparent isosurface gives an interesting view of the engine which itself is a CT scan. A logical way to then visualize a CT scan of an engine is to see it from a transparent point of view. That is, being able to see through the opaque surfaces and see how the engine appears on the inside from the outside.

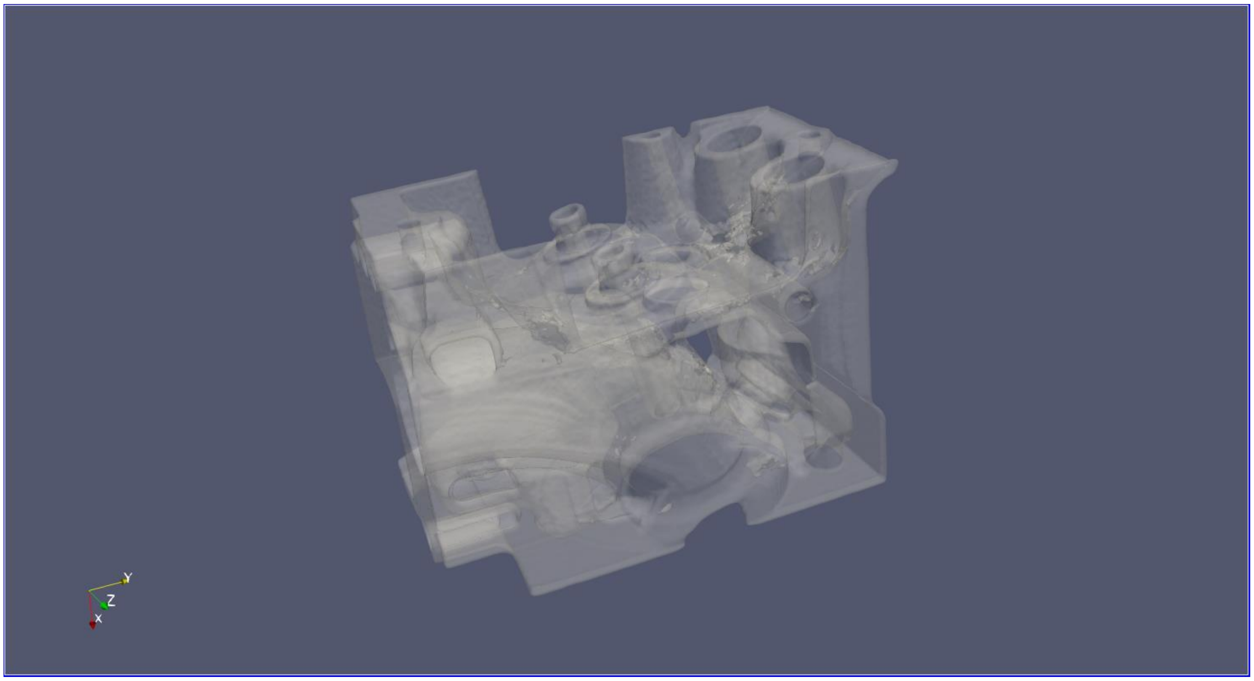

Figure 7 Transparent isosurface of the engine.

The second visualization seen below in Figure 8 is a volume rendering of the engine. The angle is slightly different from the previous visualization, but it still shows largely the same portion of the engine, except from the left rather than the right. This time, with volume rendering a different color map was used. It was learned from a tutorial that often when trying to visualize heat, the Black Body Radiation color mapping is used so that was chosen for this color scheme. The legend also shows that the temperature goes from 0 to 260. However, it's uncertain how accurate this is. It was seen in a tutorial that often the dataset will come with variables such as pressure or temperature that are correspondingly modeled within ParaView. However, this dataset didn't contain such variables and therefore it seems that the color mapping is somewhat random and superficial in terms of its usage. Using volume rendering gives a different view of the engine that is like using an isosurface.

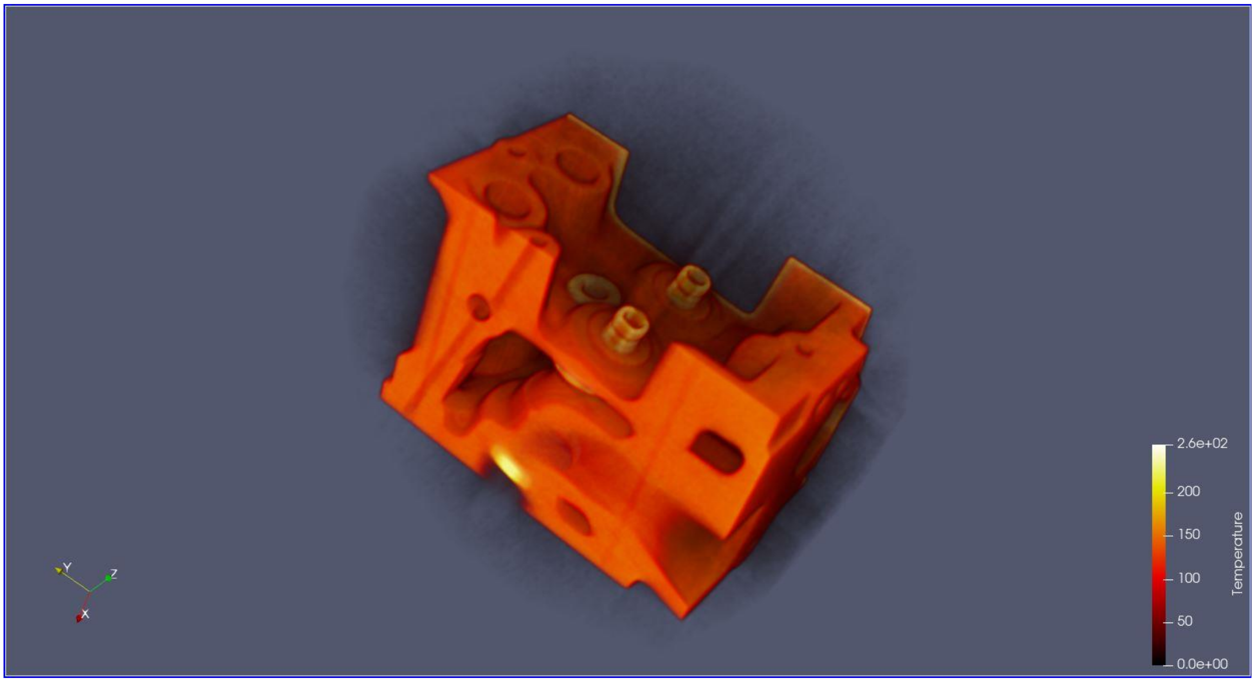

Figure 8 Volume rendering of the engine with Black Body Radiation color mapping.

The third visualization can be seen below in Figure 9. It utilizes an isosurface along with the two separate data axes to make apparent the relative sizes of the engine itself along with the glyph. However, the emphasis is on the glyphs that show some sort of output from the engine. The representation of the glyph are points and the opacity has been set to 0.2 while the isosurface has opacity 1. The reason is that this combination allows for the engine itself to remain visible and the simulated energy coming out of the engine's cylinders to also be seen. Furthermore, amongst the different possible glyph types, 'Arrow' seemed to be the most representative of what an energy output of the engine may appear like. In Figure 9, there can be seen some energy represented by points around the engine itself with a 'temperature' around 100. It seems to be the same temperature as the engine itself. It can be seen also that some distance away from the engine is some hexagon-type exhaust is created by the engine. The points from the glyph show that this energy also roughly the same 'temperature' around 100. The dataset doesn't contain variables such as temperature, pressure, or velocity and so the glyphs seem to just be some attempted simulation by ParaView to understand how energy moves in and around the engine. It seems to be showing that the engine will release some hot exhaust through the two cylinders which makes sense given that there's combustion going on in the cylinders of engines. However, there would be cylinders to prevent the energy from being released so dangerously from the engine itself. Like before, Black Body Radiation is used to help show the possible heat distribution around the engine itself. However, it's unsure how realistic the legend is given that the software seems to be making guesses since the data itself doesn't provide this information.

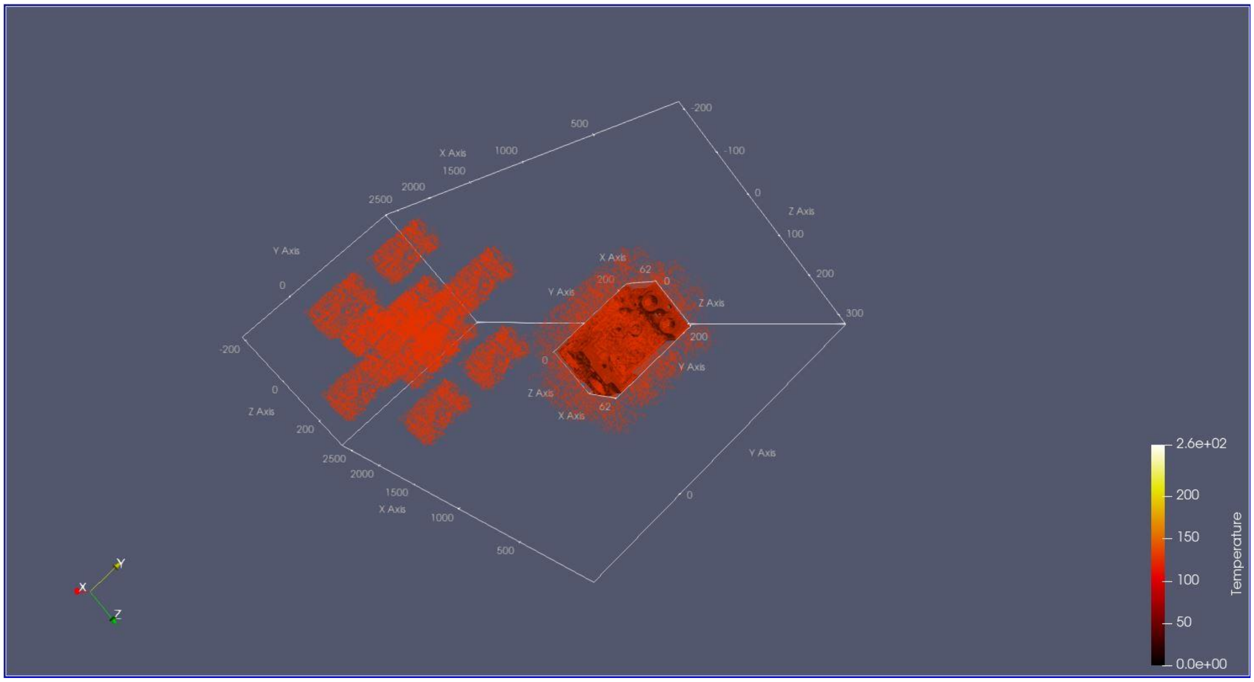

Figure 9 Glyph visualization with the engine to show energy being released from the cylinders.

References:

https://blackboard.jhu.edu/webapps/discussionboard/do/message?action=list_messages&course_id=_197180_1&nav=discussion_board_entry&conf_id=_282756_1&forum_id=_609501_1&message_id=_9688764_1

https://klacansky.com/open-scivis-datasets/sorted-by-voxels.html

https://github.com/pyvista/vtk-data/tree/master/Data

https://vtk.org/vtk-in-action/

https://www.youtube.com/watch?v=6e72yr1pXFU

https://www.youtube.com/watch?v=sLAMXfkJk7U&list=PLvkU6i2iQ2fpcVsqaKXJT5Wjb9_ttRLK-&index=11&t=0s

https://www.youtube.com/watch?v=hLeZNNQmIFk&list=PLvkU6i2iQ2fpcVsqaKXJT5Wjb9_ttRLK-&index=9&t=384s