Assignment 2 — Volume visualization

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Number of credits: 20% of the module

Recommended hours: 20–25 hours

Submission deadline: 31 March, 2020 11:00am

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1 Motivation

You are given a selection of three volume data sets. Two of the three are unknown and mysterious. Your job is to explore, hypothesize, and discover what phenomena the data sets depict through the use of volume rendering. Rather than producing a volume renderer from scratch, you are to use an existing volume renderer such as:

- The Visualization Toolkit (`http://www.vtk.org/`)
- Voreen (`http://www.voreen.org`)
- ParaView (`http://www.paraview.org`)
- InVivo (`http://www.inviwo.org/`)

to help you with your exploration. You are not restricted to the above software. You may use any volume rendering software. There are links to other open source volume renderers on the module web page. You may also Google others.

2 Tasks

The tools above are advanced, state-of-the-art volume rendering tools freely available for educational and research purposes. They are open source volume rendering libraries which enable interactive visualization of volumetric data sets with high flexibility. They are implemented as a multi-platform (Windows and

Linux) C++ libraries using OpenGL and GLSL for GPU-based rendering, licensed under the terms of the GNU General Public License. In order to accomplish this task, you are to explore the software's features (look for "Features") with a special focus on their various volume rendering techniques and transfer functions.

The aim of this assignment is to learn to use state-of-the-art volume visualization tools. Select a tool and, for each dataset, indentify the characteristics of the data and ultimately unravel what they are or what you think they are.

- Can you use volume rendering to gain an overview of the data?
- Can you discover any patterns or trends in the data?
- Does the data have any features, at a large scale or a small scale?
- What do you think the data sets are?
- What phenomena do the data sets try to capture?
- Can you support your answers with visualizations that provide evidence?

You will do this for 3 different tasks listed below.

2.1 Task 1: Getting started

Start off with rendering a known data set. We recommend you render a known data set supplied by one of the renderers from the list first. For example with Voreen, there is a standard Walnut data set. It can be downloaded from: `http://www.voreen.org/108-Data-Sets.html`. Any sample data set provided by a rendering package may be used to get started.

2.2 Task 2: Mystery Data Sets

All of the data can be downloaded from: `http://cs.swan.ac.uk/~csbob/data/`

Currently, there are two phenomena to discover, one is called Sally. Sally is an analytical data set. The other is called Betty. She is a more traditional simulated data set on a regular grid.

2.3 The Third Data Set: The Visible Human Project

For the third part, include two different volume visualizations and a description of each from the Visible Human Project: `https://www.nlm.nih.gov/research/visible/visible_human.html`. Instructions on how to download the data for the Visibly Human is available in the same online folder as Sally and Betty.

3 Guidance

3.1 Data Format Conversion

Since the field of data visualization has not yet evolved to the point of using universal data format standards, the format of the data you have been given will have to be converted to a format that your chosen program(s) can read. The input data format for each tool is described on each tool's respective web pages.

3.2 Help and Hints

- Sally is easier to identify than Betty.
- These data sets are not new. They have appeared in the scientific visualization literature many times already.
- Sally and Betty are both vector field data sets. That means they may have to be converted to scalar fields as part of the data conversion process. The vector magnitude, v, of a vector, $\mathbf{v}$, is $v = (\mathbf{v}(x)^2 + \mathbf{v}(y)2^{+}\mathbf{v}(z)^2)^{1/2}$.
- Each tool's web sites have lots of helpful documentation on how to use them.
- YouTube features helpful introductory videos on how to use the ParaView, Voreen, and other volume rendering software.
- You can post any number of questions on VisGuides.org or the tool authors for help if you run into problems.
- The teaching assistant can also help you. But don't wait until the day before the deadline.
- Some volume rendering tools can read in vector data directly, with no conversion to a scalar field necessary.

4 Submission

Your task is to produce 7 different visualizations that convey some meaningful and hopefully interesting insight about four data sets and support your hypothesis as to what they may be. The four data sets are 1) one of the sample data sets provided by the software you choose, 2) Sally, 3) Betty, and 4) the Visible Human.

4.1 Description Template

For each of your 7 visualizations, use the following template.

Image: The visualization itself as an image
Tool: The name of the tool used to generate the image
Visualization Type: The name/type of the visualization
Visual Mappings: Each of the visual mappings, e.g., color is mapped to ..., opacity is mapped to...,
Unique Observation: Things we can learn from the visualization, e.g., from this visualization we can see this pattern...

4.2 Submission

You are required to submit a report which contains:

1. Describe, briefly how you converted each data set such that it can be rendered by the volume visualization software of your choice. If the data has been modified in order to create your images, please describe the changes that were made. Please also indicate the number of hours spent on this part of the assignment for help us to calibrate the difficulty levels in future assignments.

2. **Show 7 different images** 2 different images for Sally, Betty, and the Visible Human. Only 1 sample image for the given data set accompanying your chosen software. For each data set, each of which is accompanied by a template description like in the example provided. Provide a template description for each of your images. For each data set, your volume visualization types are distinct, e.g., an isosurface and a direct volume rendering using MIP. In other words, two different isosurfaces visualizations are two instances of one type of visualization. You may submit additional visualizations, e.g., other volume visualization techniques are slicing or the various transfer functions covered in lecture.
3. **Demo via Screen Capture** Use screen capturing software to demonstrate the interaction of your application. Show what your visualizations look like when you rotate them and modify parameters such as the cutting plane position, the iso-value, or the transfer function(s). Several links to (free) screen capturing software are given on the module web page. The file(s) is named after the tool and feature(s) being demonstrated e.g., laramee16vtkSlicingAndIsosurface.mpg. The movie files are saved in MPEG or MP4 format. You may use as many screen capture files as necessary to capture the features of your application. One movie that captures all the visualizations is ideal. Blackboard cannot store very large files. Therefore, you are encouraged to upload any video demo files to YouTube or Vimeo. They do not have to be public. YouTube has a "Unlisted" option for videos making them only accessible to those with a direct link.

Submit all files: report + source code used to do the data conversion, + demo video(s) to Blackboard as a .zip file or as a .tar.gz file. Note that these are the only two platform independent file formats.