CSC337 & CSCM37 Data Visualization
Robert S. Laramee

Assignment 2: Volume Visualization
Volume Data Conversion and Discovery

Number of Credits: 20% of the module
Recommended Hours: 20-25 hours
Printed and Blackboard Submission Deadline: 23 April, 11:00am

Problem Statement
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)
- VisIt (https://wci.llnl.gov/simulation/computer-codes/visit/)
- 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.

Volume Rendering
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.

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 code you write to convert the data follows Bob's Concise Coding Conventions (Laramee, 2010). The input data format for each tool is described on each tool's respective web pages.

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. However, before you start work on unraveling the mystery data sets, 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.

Unravelling the Mystery
Your mission is to identify 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?

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 $v = (\mathbf{v}(x)^2 + \mathbf{v}(y)^2 + \mathbf{v}(z)^2)^{1/2}$
- The tools' web sites have lots of helpful documentation on how to use them.
- YouTube features helpful introductory videos on how to use the VTK, Voreen, and other volume rendering software.
- You can write to the VTK mailing list or the authors of Voreen for help if you run into problems. The same is true for the other software applications.
- The teaching assistant can also help you. But don't wait until the day before the deadline.
- A quick introduction to VTK can be downloaded from:
http://cs.swan.ac.uk/~csbob/teaching/course/laramee14vtk.ppt
- Some volume rendering tools can read in vector data directly, with no conversion to a scalar field necessary.

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.

Tasks
Your task is to produce 8 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. For each of your 8 visualizations, complete the following template:

Description Template: Provide the following information for each visualization you create:

- **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...

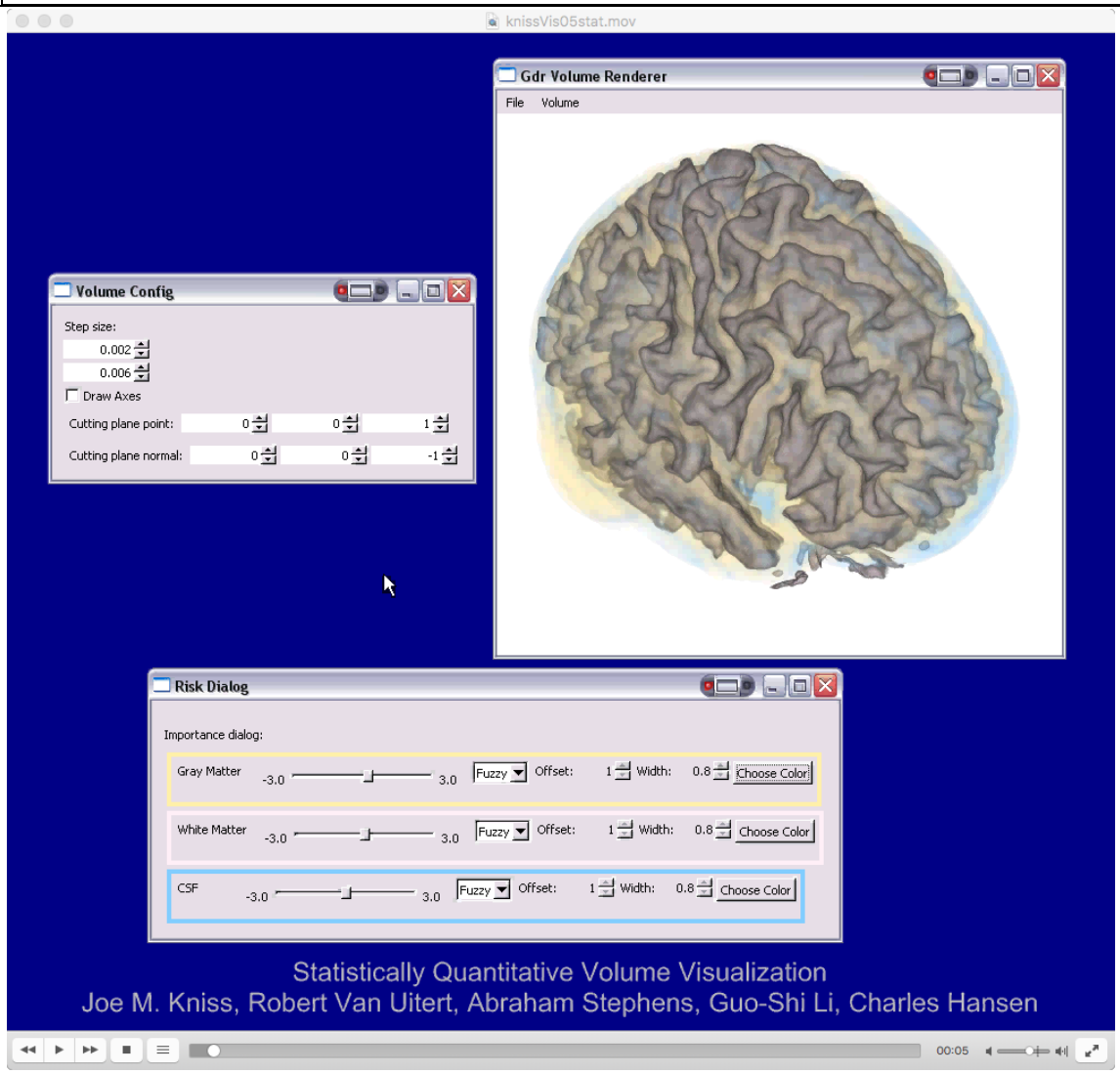

Figure 1: The first image for A1-the soft tissues of the brain depicted using direct volume rendering.

Example Description:

- **Tool:** This is a custom-built research prototype written by Joe Kniss. (It's not one of the tools available for A2.)
- **Visualization Type:** Figure 1 is a direct volume rendering.
- **Visual Mappings:** There are 3 transfer functions used, 1) for the gray matter, 2) for the white matter, and 3) for the surrounding context. Color is mapped to the tissue type. The user can interactively vary the opacity of each of the 3 transfer functions (1 per object) and create focus+context style volume visualizations.

- **Unique Observation:** We can clearly see that grey represents the tubular gray matter whereas blue represents the more fluid like white matter. The gray matter is a very intricate network of tissue. See the accompanying screen capture video demonstration.

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 8 different images: 2 different ones 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. Your animated screen captures are placed in a folder called *demo*.

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.

- Submit a ***printed color copy*** of your report.

References (Laramee, 2010) Robert S. Laramee, **Bob's Concise Coding Conventions (C^3)** , in *Advances in Computer Science and Engineering (ACSE)*, Vol. 4, No. 1, February 2010, pages 23-36 (available online)

CSC337 & CSCM37 Data Visualization
Assessed Coursework: Volume Visualization Marking Scheme and Feedback Form

Name: Student No:
Assessed By: Robert S Laramee

Basics [**20 pointsl**]

1. Is the printed report submitted in the correct format, in color, with student name? (e.g., PDF) [**3 points**]

2. Has the title, author, publisher, and publication year of a programming reference book been provided? [**5 points**]

3. Has the source code for converting the data been submitted on Blackboard and does the source code follow Bob's Concise Coding Conventions? [**12 points**] (**-1 point** for each instance of a rule violation. Rule 10, no magic numbers, is the most commonly violated rule.)

Intermediate: Visualizations [**80 points**]

1. Sample data set provided by volume rendering software

Image: [3 points]
Tool: [1 point]
Visualization Type: [1 point]
Visual Mappings: [3 points]
Unique Observation: [2 points]

Image: [3 points]
Tool: [1 point]
Visualization Type: [1 point]
Visual Mappings: [3 points]
Unique Observation: [2 points]

2. Sally

Image: [3 points]
Tool: [1 point]
Visualization Type: [1 point]
Visual Mappings: [3 points]
Unique Observation: [2 points]

Image: [3 points]

Tool: [1 point]
Visualization Type: [1 point]
Visual Mappings: [3 points]
Unique Observation: [2 points]

3. Betty

Image: [3 points]
Tool: [1 point]
Visualization Type: [1 point]
Visual Mappings: [3 points]
Unique Observation: [2 points]

Image: [3 points]
Tool: [1 point]
Visualization Type: [1 point]
Visual Mappings: [3 points]
Unique Observation: [2 points]

4. The Visible Human

Image: [3 points]
Tool: [1 point]
Visualization Type: [1 point]
Visual Mappings: [3 points]
Unique Observation: [2 points]

Image: [3 points]
Tool: [1 point]
Visualization Type: [1 point]
Visual Mappings: [3 points]
Unique Observation: [2 points]

Deductions for lateness:
TOTAL POINTS: