Interacting with Visible Human Data Using an ImmersaDesk

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Abstract

Interaction with medical volume data has often been difficult due to the large memory and computational power required. By taking advantage of current high-end graphics hardware, we have developed a volumetric virtual environment that provides the ability to help people interact with the volumetric Visible Human data set. The application enables the user to explore the interior of a virtual human body in a natural and intuitive way.

1. Introduction

In traditional medical data visualization, data were displayed in two-dimensional images. The data were obtained from X-ray computed tomograph (CT) or magnetic resonance imaging (MRI). Physicians were required to reconstruct in their mind the spatial relationship among the 2D slices of the organs.

Virtual Reality (VR) has enormous potential as a technology that can enhance teaching and training. In recent years, VR has emerged as a powerful means for interacting with scientific data in a variety of domains. It provides a new way to help scientists explore and understanding their data.

Anatomy is a cornerstone of medical education. In our work, we have created a virtual environment based on the Visible Human data set from the National Library of Medicine (NLM). Our research is intended to provide a "virtual anatomy" as an aid in medical study. We display the volumetric data directly using three-dimensional texture mapping hardware. Users can explore and examine the human body in a natural and intuitive way through a hybrid of 2D and 3D interfaces. Our system can be applied to medical education, surgical training, and surgery planning.

2. Application Design

Before building our application, we decided on the following basic design goals:

- Use VR techniques to help people in the study of anatomy.
- Use the anatomical Visible Human Male dataset to reconstruct a virtual human body.
- Allow users to explore the full body and examine specific area in more detail.
- Combine segmentation information to display specific segments only.

To achieve the above goals, different sub-tasks needed to be completed, such as data preprocessing, hardware setup, data display, and interaction design.

2.1 Data Preprocessing

The data we are using are the anatomical cross-section images from the Visible Human data set. To fit in texture memory, we created a reduced resolution full body data set with dimensions 220 x 128 x 232. We also created eight other data sets at higher resolution – head and neck, left thorax, center thorax, right thorax, abdomen, pelvis, kidneys, and left kidney. Each of these data sets can be fitted in texture memory. These images were originally in RGB format. We added one more channel (alpha) to each pixel.

The data come with mask files that contain the segmentation information of corresponding images. We processed the mask files to divide the Visible Human data into eleven different groups: circulatory, muscular, respiratory, articulations, nervous system, digestive, urinary, integumentary, reproductive, endocrine, and skeletal. The masks contain the complete information of what structure each pixel in the image represents.

2.2 Hardware Setup

The working platform is an SGI Onyx2 IR2 workstation with 64 megabytes of texture memory. The amount of texture memory limits the size of the data set that can be displayed.

Our display platform is a FakeSpace ImmersaDesk® R2. The user can see stereo images through shuttered glasses. The ImmersaDesk2 can block much of the view of the real world to create "immersion" when the user stands in front of it. The display can also be set up as a virtual surgical platform.

We are using one tracking device, the wand, which is a 6 Degrees of Freedom (DOF) joystick-like device. It has three buttons and one valuator.

2.3 Display

We are using OpenGL Volumizer™ to render the data. OpenGL Volumizer is an application programming interface (API). Volumizer can take advantage of the specialized three-dimensional texture memory in a graphics workstation to achieve fast display of volume data. The final images were created by blending the slices using blending hardware.

We use CAVElib, a virtual reality API, to obtain the button input and position and orientation of the tracking device during the interaction. We chose not to use CAVElib to create the stereo view, because CAVElib renders in RGB mode only and we need the additional alpha channel to achieve some special effects.

2.4 Interaction design

For interactivity purposes, our application allows users to interact with the low-resolution full body data set (220x128x232) in the beginning. After they have finished examining the full body, they can select any of the other predefined areas to explore in higher resolution.

We have created two different versions of our work. The main differences between them are the interface and the interaction methods.

Interface I: This interface was created using Motif widgets. The drawing area can be either in stereo-mode or in normal mode. During interaction, only 2D movements of the tracking devices are tracked. Users can learn how to perform the tasks in a short period of time if they are familiar with traditional mouse input. It is intended for people who are not used to or do not have 3D devices and a workbench display.

Interface II: In this version, we have created a floating widget system in the virtual environment. By touching these widgets and pressing or holding a button, or adjusting the valuator, on the wand, the user can slice, rotate, or change the attributes of the data. The floating widget system includes a rotation bar, text plates, and a global scale box. The rotation bar is a rectangular box with text on four sides of its surfaces. The user can bring up different functions by pressing the button on the wand to rotate the rotation bar. The text plates show different options that the user can choose by using the wand to touch the screen location of these text plates. The global scale box is a very simple miniature model of the world made of line segments.

3. Results

We have created a virtual environment that allows users to interact easily with the volumetric Visible Human data set. Users can explore the human body at different levels of detail by loading selected subsets to examine different organs at higher resolution. We have achieved very promising results in developing programs and techniques for these tasks.

With the stereo view enabled using the first type of interface (Motif GUI), one operator (or instructor) can perform the tasks in front of the monitor and the observers (students) can stand in front of the big screen to see the results. This is a good method for demonstrating results to a group of observers. If an observer wants to perform tasks himself, he can load the driver to let the wand act like a mouse or bring up a second interface to let the user operate it.

4. Conclusion and Future Work

By using the Volumizer API to take advantage of the underlying 3D texture memory of the SGI workstation, we have created a useful VR application that provides an easy-to-use interface to help users in studying anatomy. Compared to traditional medical data visualization methods, our work has the following advantages:

- It improves the understanding of spatial relations between different organs by using stereoscopic views.
- Users can perform the tasks more easily and intuitively.
- The routine can be performed repeatedly without the cost associated with actual dissections.

The main bottlenecks of our application are the display latency and the loading time when loading a different dataset. The loading time problem may be solved by loading all the data in the memory at the beginning of execution. To solve the latency problem, we may have to wait for new computer architectures.

Currently we have nine different predefined segments to display. We are building an administrative interface so users can choose interesting segments to display before they execute our application. We have performed some informal test with physicians; they were interested in higher resolution display and more detail of some organs. However, a comprehensive study of the users' responses to the interaction design is still needed.

5. Reference

[1] Ching-yao Lin, "*Interaction with Medical Volume Data on the Responsive Workbench*", Ph.D. dissertation, Depart. of Computer Science, University of Houston, May 2002