VISUALIZATION, ANNOTATION, AND EXPLORATION OF THREE DIMENSIONAL DATASETS USING AN EXISTING 3D RENDERING SYSTEM

BIOENGINEERING

Author: S. Janna Balling. Advisor: Chris Johnson, SCI Institute
j.balling@utah.edu, crj@sci.utah.edu

SCI INSTITUTE

THE UNIVERSITY OF UTAH

ABSTRACT

The demand for user-friendly tools to view three dimensional (3D) volumes and create original annotations in real-time has increased with 3D volume exploration popularity. This project developed a tool, Annot3D, that allows users to easily compose xml text instructions to visualize original Computed Tomography (CT) volume datasets, add useful, simple annotations, and explore the data in real-time. Annot3D was composed of many modules designed to interact with an existing, complex rendering system called the Visualization Tool Kit (VTK).

INTRODUCTION

Current 3D annotation software packages, such as VoxelMan[3], Digital Anatomist[2], and Anatomy Browser[1], do not allow the use of original datasets and/or prevent real-time 3D exploration. Presently, interactive 3D volume viewing can only be accomplished through real-time rendering software which requires complex computer programming knowledge to use.

Creating a user-friendly tool that provides original 3D volume viewing, annotating, and real-time exploration presents the following design challenges:

1. The tool needs to render volume datasets from popular acquisition techniques, such as Computed Tomography (CT).
2. Annotations should be useful in labeling, highlighting, and exploring the data. Annotations such as spheres, text, and lines should be three dimensional so that users can view the annotations from any angle.
3. Viewing of the volume should be controlled by the user, allowing the user to see any perspective of the volume.

METHODS

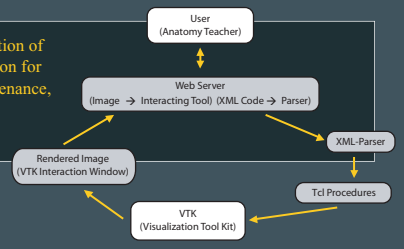
A solution to the previous design challenges was using an existing software package, the Visualization Tool Kit (VTK), to render and manipulate the scene. A more user-friendly authoring and exploration tool was then created to interact with the complex VTK software.

This project created a software tool, named Annot3D, to allow users to easily compose text instructions to:

1. view 3D volume datasets
2. create annotations
3. interact with the scene in real-time.

Annot3D was organized into modules (Figure 1) that were each chosen to perform a specific task with the overall software goals in mind.

Fig. 1. The module composition of Annot3D provides organization for software development, maintenance, and executability.



RESULTS

Visualization Tool Kit (VTK) is a collection of many complex functions including those to visualize 3D datasets, render 3D shapes and text to use as annotations, and adjust and the viewing angle of the rendered images. The resulting images are displayed in the **VTK interaction window** where users can update the scene using additional functions or mouse movements.

Fig. 2. Basic VTK objects, including the sphere, cube, line and text objects, were used as annotations in Annot3D.

VTK functions were packaged using the Tcl programming language into **Tcl procedures** which condensed the complex VTK function calls into simple command line calls. Procedures were written for visualizing CT data, adding annotations (Figures 2 and 3), and interacting with the scene (allowing users to rotate, translate, zoom, pick annotations, or produce two dimensional pictures of the interaction window).

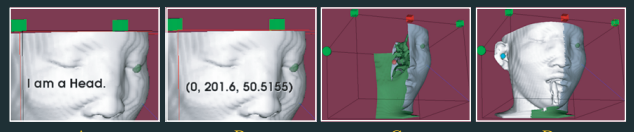


Fig. 3. The PointPicker annotation allows users to switch between normal picking (A) and picking to display data coordinates (B). Clipping annotations can be used to explore the inside of a dataset (C) or highlight a large area of a dataset (D).

A text **parser** was used to interpret the xml text instructions created by the user (Figure 4). The xml code was designed to correspond with each Tcl procedure in Annot3D and provides the interface for users to run Annot3D.

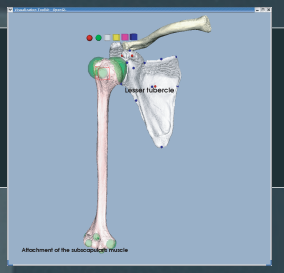
Fig. 4. The user provides instructions in xml code. This example creates a dot annotation with the desired values for the color, opacity, radius, and center location variables.

```
<dot name="demodot" visibility="On">
 <color>
  <red>0</red>
  <green>1</green>
  <blue>0</blue>
 </color>
 <opacity>.30</opacity>
 <radius>5</radius>
 <center>
  <x>133.5</x>
  <y>167.9</y>
  <z>33.32</z>
 </center>
</dot>
```

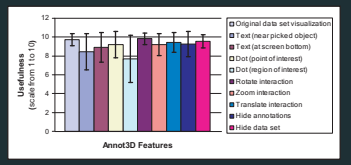
The TclHttpd **web server** was used to optionally extend Annot3D to interact through a web page. It allows multiple users to access and use one copy of the software from any web browser. In order to run commands from multiple users, a Client ID was integrated into the Tcl procedures to keep track of the multiple scenes.

The Annot3D software was tested by a group of anatomy professors at the University of Utah who downloaded and used the software to create original models of three shoulder bones (Figure 5).

Fig. 5. CT scans of the clavicle, humerus, and scapula were taken at the University Hospital. Annot3D was used to visualize the data and add annotations to demonstrate the anatomy and spatial relationships of the bones.



The effectiveness of the Annot3D features were determined by a survey given to eleven medical students who participated in a demonstration from the anatomy professors. Survey results (Figure 6) confirmed the usefulness of the features of Annot3D especially in an educational setting and provided a positive outlook towards future use of the software.



Measurement	Average Survey Result (scale from 1 to 10)
Overall effectiveness for learning anatomy	somewhat useful (5) to very useful (10)
Effectiveness of Annot3D vs. printed atlases and textbooks in learning the names of anatomical structures	Somewhat better (7)
Effectiveness of Annot3D vs. printed atlases and textbooks in terms of helping students to gain a mind's eye view and learn spatial relationships	Significantly better (10)

Fig. 6. Survey results show the usefulness of the Annot3D features (left) and the effectiveness of using Annot3D for anatomy education.

DISCUSSION AND CONCLUSIONS

The Annot3D software fulfilled the major goals of this project. Users can easily compose xml text instructions without having complex computer programming knowledge. They can visualize original CT volume datasets and add useful, simple annotations. They can explore the data in real-time using either the mouse in the VTK interaction window or xml code for interaction commands. Annot3D can also be run through the TclHttpd web server.

REFERENCES

[1] Anatomy Browser: open-source copyright. 25 Jan 2004
[2] Digital Anatomist Interactive Atlas, University of Washington, 1997: 25 Jan 2004
[3] Voxel man, Springer-Verlag Heidelberg New York, 2003: 25 Jan 2004

I would like to thank Jenny Simpson who was my partner in development of Annot3D. Thanks also to Dr. David Morton and Kenneth Foreman for their help with obtaining CT data, using Annot3D, and demonstrating Annot3D in the classroom. Funding for this project was provided by a grant from the National Science Foundation (grant#ACI-9619019 PI - Chris Johnson, Ph.D.).

Annot3D Home page
www.sci.utah.edu/~balling/Annot3D
Scientific Computing and Imaging Institute
www.sci.utah.edu
Tcl Developer Site
www.tcl.tk
VTK Home Page
www.vtk.org