# USING WEB3D TECHNOLOGIES TO VISUALIZE AND ANALYZE CAESAR DATA

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The CAESAR (Civilian American and European Surface Anthropometry Resource) project completed in 2002 has collected 3D scans of over 5000 subjects. We have created several 3D visualization tools, utilizing the Virtual Reality Modeling Language (VRML) to provide 3D access via the Web. In addition to simply viewing the 3D scans we have augmented the display of the body with interactive anthropometric landmarks and contour line displays. We have also demonstrated several different techniques for adding motion to the static 3D scans. The use of motion capture data, in particular, opens up new avenues for anthropometric research as applied to a number of engineering design tasks.

## INTRODUCTION

In an effort to improve the usability and utility of CAESAR (CAESAR 2002) data we have developed a Web3D viewer and some translation utilities which add functionality to the data. In addition we demonstrate that by translating data into standard formats we increase the interoperability and utility of several data formats. Viewing the 3D data with real time manipulation capabilities in the context of rich media web pages improves the utility of the data.

## VRML CAESAR VIEWER

The CAESAR project completed in 2002 has collected 3D scans of over 5000 subjects. We have created several 3D



**Figure 1 NIST CAESAR Viewer implemented in VRML**

visualization tools. First the NIST CAESAR Viewer (NCV), which utilizes the Virtual Reality Modeling Language (VRML 1997) to provide 3D access via the Web. In addition to simply viewing the 3D scans we have augmented the display of the body with interactive anthropometric landmarks and contour line displays. The landmarks and viewpoints associated with the landmarks are automatically placed onto the body as a visual anthropometric glossary. Display of the contours boundaries are adjusted by the user moving sagittal, coronal and transverse cutting planes.

The NCV system, illustrated in Figure 1, uses landmark coordinates from the CAESAR data set to automatically place the landmark spheres on the surface of the scans. Each sphere is made interactive. This was implemented by using VRML TouchSensors so that the landmark data pops up when the user places the cursor over the landmark spheres. We automatically generate points of view, using VRML Viewpoint Nodes, associated with each landmark to allow the user to get close-up views of the landmarks in context of the body. We generate the viewpoints by surrounding the body with an enclosing cylinder and drawing a vector from the landmark to the cylinder. The intersection point between the vector and the cylinder becomes the viewpoint for that landmark. The end result is a system that automatically generates views of the landmark spheres, places them on the body and automatically generates associated viewpoints for each landmark. These interactive bodies are the equivalent of our previous "AnthroGloss" (Ressler, 2001) body however they are now generated automatically for each CAESAR body rather than manually constructed for a particular synthetic
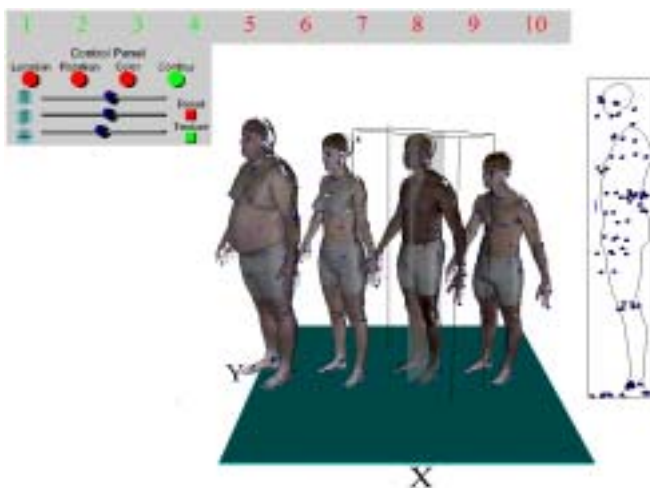
body.

Our current version of NCV, includes the ability to toggle on or off body textures, landmarks, and contours. It also provides the ability to select a color for the entire body. Labels for the control slider change as appropriate to match the particular functionality selected.

The controls currently available to the user allow for the display of multiple (up to 10) bodies. The control panel operates on the "current" body indicated by a box surrounding the body. The "current" body is selected by simply clicking the body. Contour lines associated with sagittal, coronal and transverse cutting planes can be displayed. When the user selects a cutting plane an animated display of the contour cut plane is created and the user can drag the cutting plane through the body watching the effect on the contour. Finally the user can measure distances on the contour display by selecting start and end points on the contour lines. The distances are in the same units as the original CAESAR data.

## STATIC TO REAL TIME

We also utilize Web3D to bring dynamic visualization to an otherwise static display. The initial data we start with is in the ply format and read/write utilities are provided by Cyberware the company that manufactures the whole body laser scanner used by the CAESAR project. We created a small C program to generate our own VRML files rather then the translator provided by Cyberware,
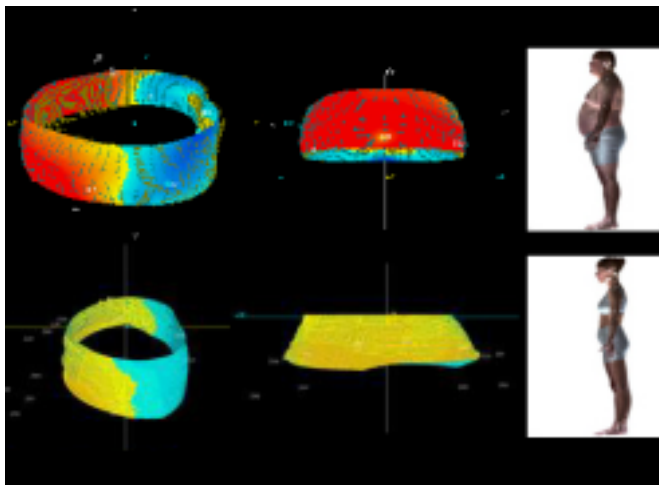


**Figure 2 Comparison of large and thin person's belly comparing standing and seated positions. Left and frontal views of belly slice with shading changes representative of shape differences.**

which is somewhat out of date.

We wanted to investigate the possibility that the static body scans could be used to help analyze the skin deformation of the midsection. The question was can we measure how much a belly deforms when someone sits versus when standing? The CAESAR dataset contains scans of each subject in three positions two seated, and one standing. We simply slice out the belly of the subject in one of the seated positions and compare that to the belly of the same subject while standing.

This "beer belly" analysis is primarily done inside of the Integrate (Integrate 2000) software, which can generate a radial difference map, which colorizes the difference between two surfaces. While Integrate is highly functional it suffers from a poor user interface and cannot allow any real time animation or interaction with the model. Figure 2 illustrates the belly slices displayed with Integrate with the colors used to display the depth differences between the seated and standing figures. We next translate that colorized model into VRML allowing the researcher to view the visualization in real time. The resulting slice of belly can be viewed and spun around in real time. The next obvious task, which we leave to the reader is to add interaction with the object such as a display of the numeric difference between the surfaces when the cursor is over the surface.

## ANIMATING STATIC BODIES

### Hand Animation

Our first attempt at animating the static CAESAR bodies took advantage of H-ANIM (H-ANIM 2001) by using an existing well known animation, the so called Nancy (Ballreich 1997) example. This hand produced animation, was often used as a test file to explore the functionality of VRML browsers and H-ANIM. The Nancy file contains animations for walking, running and jumping with controls to select each. Theoretically if you have a compliant H-ANIM figure you should be able to simply reuse the Nancy animations. This did in fact turn out to be true and we produced convincing animations of the CAESER figures illustrated in Figure 3.

### Motion Capture

Motion capture data, the data obtained from sensors a subject wears while moving is a rich source of data for ergonomic analysis. In an effort to improve the utility of motion capture data we have developed a BVH (Biovision)

to H-ANIM translator. We started the process finding an existing converter (Lewis 2001)! Matt Lewis of Ohio State created a partially complete converter which we modified. By converting motion capture data into a standard representation for humanoids we hope to increase the interoperability between motion capture systems and analysis programs.

BVH a commonly used motion capture format is translated into the H-ANIM format a forthcoming ISO standard for representing the hierarchy of humanoid figures. Originally tied to the VRML standard the H-ANIM standard is language independent, however in this case we simply used the VRML version of H-ANIM.

BVH files contain several "channels" of motion information. Each channel corresponds to the motion of a



**Figure 3 CAESAR figure in VRML with "Nancy" animation produced by hand.**

limb. The motion of each limb is relative to the position of its parent in the body hierarchy and motion assumes a known starting position.

In order to animate CAESAR models we must first segment the single mesh of polygons from the original ply file and create a set of meshes each corresponding to a particular limb. The limbs are reattached creating a complete body hierarchy. The segmentation is very crude and consists simply of straight planar cuts utilizing the Integrate software. An Integrate script was developed which uses the anthropometric landmarks as reference points for the segmentation script, which is able to function completely automatically.

Next the newly created limbs, still in the ply format are reduced in complexity using the QSLIM (Garland 1997) utilities which are both very fast and have the ability to maintain textures while reducing the polygon count. Next the reduced polygon mesh, now in the smf format is converted via a custom C program into VRML. Finally the VRML limbs are reattached following the H-ANIM standard.

Once in H-ANIM format we use the BVH data to repose the body. The translator parses the BVH file obtaining a set of VRML OrientationInterpolator nodes for the body joints, and ROUTE nodes to link the Interpolator nodes to the H-ANIM body joints. Figure 4 illustrates three frames resulting from this process.

The H-ANIM format requires the body to have both geometry for each limb and joint centers specifying points of rotation. Given that the original data is of the surface of the body there is no explicit joint center information. Therefore a series of heuristics is used to effectively estimate all the joint centers. These derived joint centers are used in the H-ANIM model we construct. The program genHanimWrl.c takes as input the landmark file plus all the limbs and computes the joint centers and assembles the limbs into the correct hierarchy.



**Figure 4 Three frames of a motion capture sequence from BVH file controlling a CAESAR body in VRML browser.**

## CONCLUSIONS

We have demonstrated several techniques for using CAESAR data in a number of Web3D application areas. Utilizing the landmark files and the surface scan data we can apply motion capture files to animate the static CAESAR bodies providing users with clear visual feedback to the motion of interest. These Web3D techniques demonstrate the practicality of using Web3D to add functionality to static 3D human models giving end users access via simple Web browsers.

## ACKOWLEDGEMENTS

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