3D Visualization of Visible Human Data

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The Visible Human Project

- Funded by the National Library of Medicine implemented at the University of Colorado HSC.
- 39 - year old white male who donated his body to science after being convicted of murder and sentenced to death.
- Magnetic Resonance Images(MRI- 256x256x12) - head scanned axially, the other sections scanned coronally.
- Computer Tomography (CT - 512x512x12) - soft tissue and bones.
- Anatomical color photographs - 1878 transverse slices, each 1 mm wide; each slice of original data is a 2048x1216 pixel 24-bit color image.
- NPAC has obtained a copy of the Visible Human data set 14GB and license to use it.
- Female VH not downloaded : 5,000 cross sections (40 GB). Good for 3D reconstruction (cubic voxels, 0.33 mm size)

Data Preparation

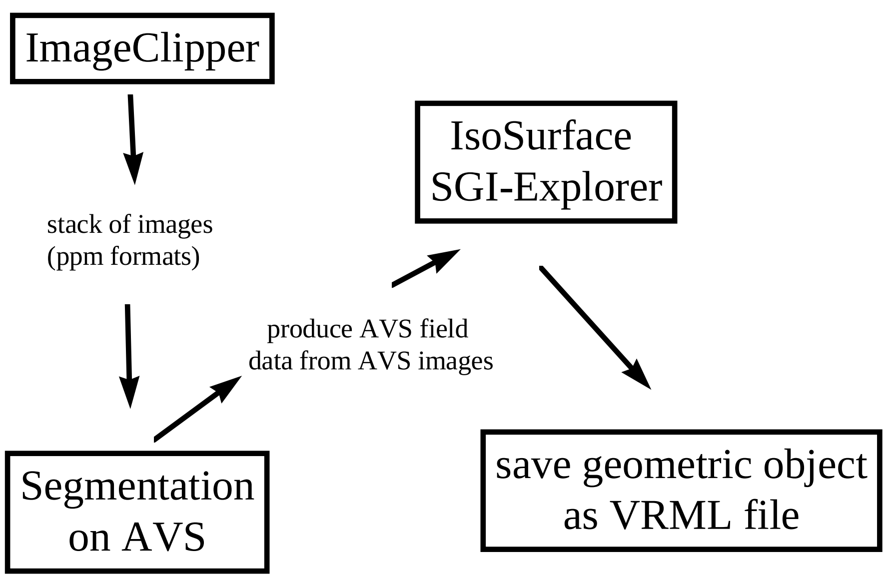
- We have cropped the original images and removed the gelation background.
- We have constructed slices in two orthogonal panels (sagittal and coronal views); aligning required - linear interpolation between slices; best fit of features as a function of translations and rotations.
- The resulting images were converted to PPM formats (1728x1878).
- Image Clipper Application program (written in java) allows to cut the selected portion of the image and to apply the procedure to all images in the stack (head - 256x316 700 images)
- Data stored in voxel representation in Illustra object-relational database (x,y,z,r,g,b).

Java based 2D Viewer

- The NPAC Visible Human Viewer is an interactive graphical interface written in Java (browsing 2D images).
- Java applet allows to select and view high resolution images of
  2D slices (axial, coronal, sagital) of the human body.
- The lower resolution data for easier downloading (medium and low resolution) is created.
- In December 1995, NPAC Visible Human Viewer was awarded two JARS (Java applet Rating Service) Awards and was featured on the February 17, 1996 episode of “Computer Chronicles” on PBS.
  In May, the Viewer received Java Cup International Award
  http://www.npac.syr.edu/projects/vishuman/VisibleHuman.html

Segmentation

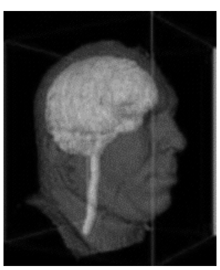
- Automatic segmentation is not possible on anatomical images.
- Interactive, semiautomatic segmentation is time consuming (one man-year to segment 300 anatomical objects)
- Algorithms (histogramming, thresholding, edge enhancement)
- Image volume must be segmented into its anatomical constituents.
- Minimum distance classifier written in C on AVS.
- Segmentation was also implemented in Java.
- Bone tissue cannot be separated from anatomical images.
- We must come back to CT images and do aligning of CT images and anatomy images.



Current Procedure

- Segmentation done using modules written C on AVS.
  - minimum distance strategy
  - time consuming
  - human assistance necessary (training stage, inspection and correction of misclassified pixels on each slide).
- Surfaces are extracted from AVS field data by using SGI-Explorer isosurface algorithms.
  - aliasing problem (steps) - geometric smoothing
  - holes on surface
  - data reduction 2 mm x 2 mm x 2 mm (downsampling)
  - transmission time - surface/polygon simplification
- Conversion to VRML

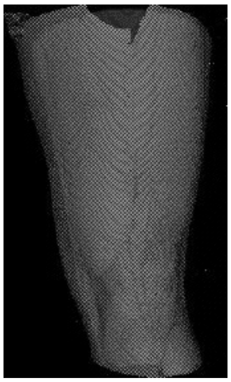
Head



» Volume Dimensions: 104 x 144 x 119
» Pixel Dimensions: 2 mm x 2 mm x 2 mm
» Pixel Depth: 24-bit (8-bits x RGB)
» Volume Size: 5.4 MByte (as AVS field data)
» # of Points in vrml file : 85216
» # of polygons : 23739
» the size of vrml file : 8014534 Byte (ascii)

Brain

» Volume Dimensions: 104 x 144 x 119
» Pixel Dimensions: 2 mm x 2 mm x 2 mm
» Pixel Depth: 24-bit (8-bits x RGB)
» Volume Size: 5.4 MByte (as AVS field data)
» # of Points in vrml file : 32656
» # of polygons : 8667
» the size of vrml file : 3035864 Byte (ascii)



Leg

» Volume Dimensions: 112 x 184 x 112
» Pixel Dimensions: 2 mm x 2 mm x 2 mm
» Pixel Depth: 24-bit (8-bits x RGB)
» # of Points in vrml file : 216146
» # of polygons : 56626
» the size of vrml file : ~18M Byte (ascii)

Plan

- improve : speed, transfer time
- geometric smoothing
- Fly through
- Interactive visualization (manipulation, extraction of multidimensional medical structure)
- Animation (MPEG)
- Integration with Illustra database