Advances in Forensic Anthropology

Technology Transition Workshop

Improving Forensic Facial Reproduction Using Empirical Modeling

Attendees will learn of an approach for forensic facial reproduction that uses empirical modeling during this session. The process of using a portion of the known landmarks traditionally accessed for facial reconstruction prediction, while also incorporating the effect of body mass index (BMI) in the empirical model, will be described. Unlike current forensic facial reconstruction techniques that use average facial tissue depths from a population sample of individuals, the technique applied during in this workshop session will use a non-parametric empirical model to predict facial tissue depths that are unique to each cranium. Attendees will discover that this technique also has potential to predict facial features like the eyes, nose, and ears. The purpose will be to learn to use this technique to generate more accurate facial reconstructions, thus improving forensic facial reconstruction by enhancing the accuracy of soft tissue thickness prediction.

Technology Transfer Session 2: Segmentation Hands-on

The first portion of the Technology Transfer Session 2 will be segmentation. The primary focus of the segmentations hands-on session will be ensuring that attendees gain an understanding of a software program that which will be utilized to create a three-dimensional model of the cranium from a computed tomography (CT) scan. Attendees will be guided through a step-by-step demonstration of the software program, leading to the full completion of an accurate 3D cranium model. Efficient and accurate completion of this process is essential prior to moving forward with the tissue and bone measurements.

Segmentation Hands-on

Avizo is a commercially available program that will be used to create a 3D model from CT data. The user interface is divided into five parts: (1) the 3D viewer, (2) the Pool, (3), the Properties area, (4) the Console window, and (5) the help browser. It will help to remember these areas by name, as they will be referred to throughout the instruction guide. Segmenting a dataset means to assign each pixel within the image to a region. These regions are represented by materials with the program. This segmentation process must be completed prior to generating a surface model which can be used to record bone and tissue measurements from the cranium.

Loading Dataset

Each attendee has been provided with a DVD containing a CT crania dataset. Insert the disc into the computer and follow the directions below to load the dataset in Avizo.

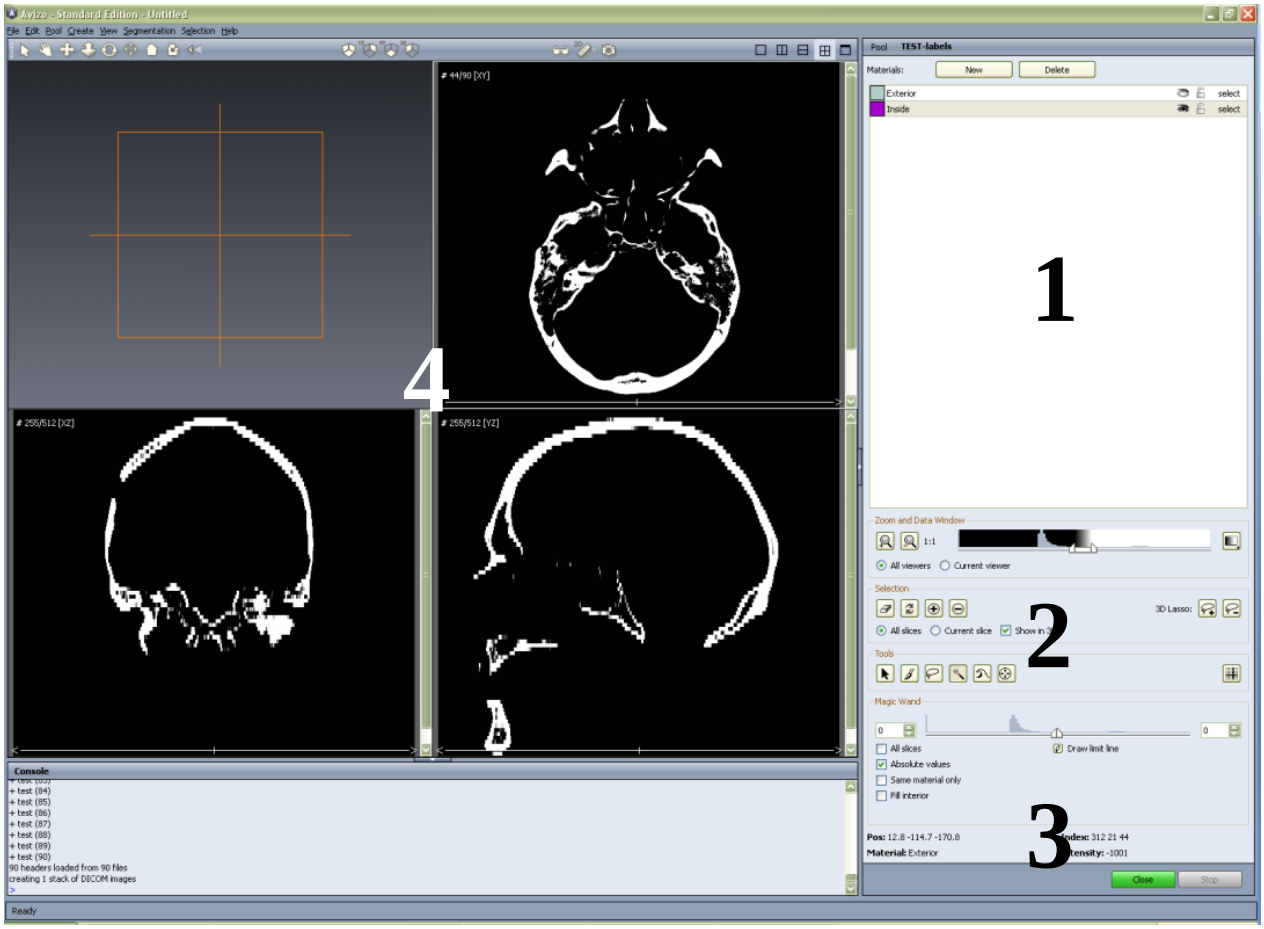
- Open Avizo
- In the Pool, click on Open Data...
- Select the DVD drive location and load all dicoms in the folder by clicking on the first file, holding down the Shift key, and selecting the last file
- Select **OK**
- A data object (represented by a green icon in the Pool) will appear just below the Open Data... button containing all dicom images

Segmentation

- Click on the green data icon with the left mouse button to select it
- To crop the dicoms and remove any unnecessary data, click with the right mouse button and select **BoundingBox**
- Right click with the mouse button two more times each time selecting **Orthoslice**
- In the Properties area, scroll through range slider in the Slice Number to determine the boundaries for the cranium (default orthoslice will be in the orientation of xy). Make a note of the slice numbers on each side of the cranium, making sure not to end the boundary before the mandible has disappeared from the image.
- Click with the right mouse button and select **Compute** and then **Resample**
    - In the Properties area, select **Cubic, width 8** from the Filter dropdown menu
    - Click on **voxel size** in the Mode option and change the **x**, **y**, and **z** value from to **0.8**
    - Select 

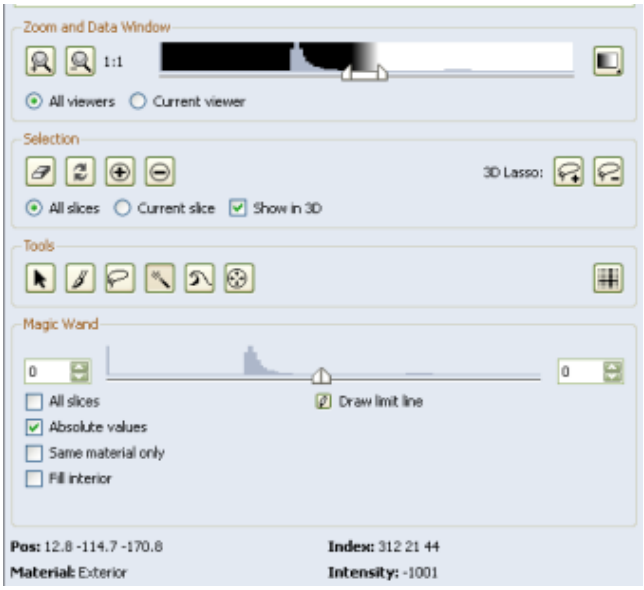
 at the bottom of the screen
- A new file with the extension ".Resampled" will appear in the Pool
- Click with the right mouse button and select **Compute** and **Castfield**
    - In the Properties area, **unsigned char (8 bit)** should be selected in the Output Datatype dropdown menu
    - Select 

 at the bottom of the screen
- A new file with the extension ".to-byte" will immediately appear in the Pool
- Click with the right mouse button and select **Labelling** followed by **LabelField**.
- A new window will open splitting the 3D viewer into four sections and providing a selection of segmentation tools on the right hand side of the screen.



Once open, you can see the Image Segmentation Editor window is divided into four major parts: (1) material list, (2) tool box, (3) info area, and (4) image viewer(s). The materials list is a list of materials found in the upper right corner. Here you can add, remove, rename materials, and select the current material. The tool box is found below the material list and has several tools for interactive manipulation of the segmentation. Depending on the currently selected tool, additional widgets show up in the options frame. The info area is located below the tool box and contains some basic information like the current cursor position or the material under the cursor is displayed. Finally, the image viewer(s) is the largest part of the window is and covered by one or four image viewers, displaying the labels and the current selection in differently oriented slices.

Before beginning the segmentation process, it is important to become familiar with the tools available in the Avizo program. Below is a view of the bottom right hand section of the screen once the Labelfield has been opened.



The primary tools needed for this type of segmentation are separated into selection tools and segmentation tools:

Selection tools:

Two radio buttons let you choose between *all slices* or *current slice*. The 3D toggle is activated when *all slices* is selected and, when activated, the selection tools in this group operate in 3D mode. ***Currently, no undo is available in 3D mode. Therefore, be very cautious when activating the 3D toggle.***

Clear: This button clears the current selection. If the 3D toggle is activated, the selection is cleared in all slices.

Add: This button adds the selected to the material currently highlighted in the material list.

Subtract: This button subtracts the selected from the currently highlighted material in the material list.

Segmentation tools:

Pick and Move: This tool selects a connected region assigned to one particular material by clicking on an image voxel with the left mouse button. If *select all* is checked, all voxels belonging to the same material as the clicked voxel will be selected, either in 3D or in the current slice only, depending on the value of the 3D toggle.

Brush: This tool allows you to select regions by painting voxels with the left mouse held down. The size of the brush can be modified via a slider in the tool's control panel, while some dedicated brush sizes are provided just below the slider. Pixels can be deselected by holding down the *Ctrl* key.

Lasso: This tool lets you define an area by generating a closed contour curve.

Line segments are automatically fitted to the image edge when the *auto trace* option is enabled. Click with the left mouse button to define a starting point, release the button, and then drag the mouse along the image edges. Additional mouse clicks will further fix the line along the contour. If the contour does not close, click with the right mouse button to complete the closed curve.
 Blowtool: This tool is used to generate a circle-shaped contour within a space. Click with the left mouse button on a voxel and, without releasing the button, drag the mouse. The contour will continue to grow the further the distance from the initial position of the mouse click.

It is also important to note some keyboard shortcuts.

"C" will clear your selection
"D" will change the shading of the regions that have been added to one of the materials
"+" will add the current selection to the highlighted material
"-" will subtract the current selection from the highlighted material

To proceed with the segmentation:

- In the 3D viewer, click on **Selection** and then select **Threshold...**
    - Set the minimum value to 150 and the maximum to 255
    - Select **All slices** and hit **Apply** and then **Close**
- Add the selection to the Inside material. To do this, be sure the Inside material is highlighted and click on the  button.
- Once the segmentation is complete, click  in the bottom right hand side to go back to the main window.
- Save your segmentation labels by clicking on **File** and then **Save Data As...**

** Look for any scattering along the regions of the teeth where metal fillings could be.

** Make sure that only the cranium and mandible are included in your segmentation. You may have to change between the three views (xy, xz, and yz) to best identify the separation between the occipital bone and vertebrae. If you have a very difficult time distinguishing between the base of the cranium and the vertebrae, it may be best to generate the 3D model and use the orthoslice tool in order to help determine the exact location of the separation. If you feel this option is necessary, please proceed to 3D Model Creation. Details are provided in the next section.

- To change the orientation of the image, select **Segmentation** and then **Orientation** and the orientation of your choosing: xy (axial), xz (coronal), or yz (sagittal).

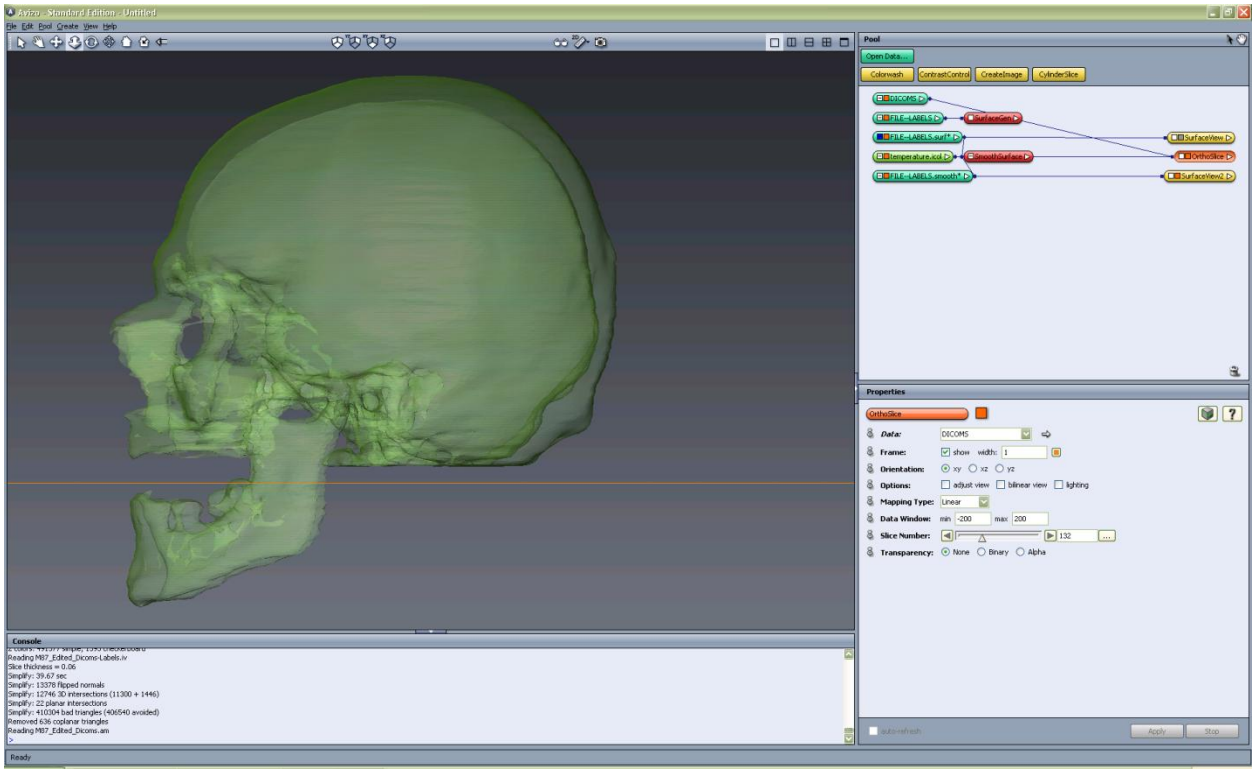
3D Model Creation

- Click with the right mouse button and select **SurfaceGen**
- Select **none** from the Smoothing dropdown menu
- Select 

in the bottom right hand corner and then hit **Continue**
- A new data object will appear in the Pool with the extension .surf
- To view the file, click with the right mouse button and select **SurfaceView**
- Click with the left mouse button on the surface data file to make sure the file is selected. In the Properties area, select the simplifying tool 
- Enter 100,000 faces in the Simplify section
- Check **preserve slice structure** and then click on **Simplify now**
- Click with the right mouse button on the .surf data file in the Pool and select **Compute** and then **SmoothSurface**
- Enter 20 iterations in the Parameters section and click 

- A new data object will then appear in the Pool with the extension .smooth
- To view the 3D model, click with the right mouse button on the smooth data file and select **SurfaceView**
    - To change the view of the model, left click with the mouse button on the .surf data file to select the file.
    - Select one of the options in the Draw Style dropdown menu to change the view. Transparent is the option shown in the image below.

Check the model for any major defects derived from the segmentation. If a portion of the model needs to be corrected, you must re-open the LabelField to correct any errors. To do so, click on the green data file with –labels in the name and then click on  in the Properties area to re-open the Image Segmentation Editor. A useful tool to use in case of inaccuracies within your 3D model is the orthoslice. Right click with your mouse button on the original data file containing the dicom images and select **Orthoslice** (shown as the horizontal orange line in the image viewer). An orange orthoslice box will appear in the Pool. Click with the left mouse button to select the file. In the Properties area, you may move the location of the orthoslice by using the range slider in the Slice Number. If a defect is present, you may use the location of the orthoslice to identify the slice number where the defect exists.


Pool
Open Data...
Colorwash
ContrastControl
CreateImage
CylinderSlice
DICOMS
FILE-LABELS
FILE-LABELS.surf*
Temperature.icol
FILE-LABELS.smooth*
SurfaceGen
SmoothSurface
SurfaceView
OrthoSlice
SurfaceView2
Properties
OrthoSlice
Data:
DICOMS
Frame:
show
width: 1
Orientation:
xy
xz
yz
Options:
adjust view
bilinear view
lighting
Mapping Type:
Linear
Data Window:
min -200
max 200
Slice Number:
132
Transparency:
None
Binary
Alpha
Apply
Stop
Console
Reading M87_Edited_Dicoms-Labels.iv
Slice thickness = 0.06
Simplify: 39.67 sec
Simplify: 13378 flipped normals
Simplify: 12746 3D intersections (11300 + 1446)
Simplify: 22 planar intersections
Simplify: 410304 bad triangles (406540 avoided)
Removed 636 coplanar triangles
Reading M87_Edited_Dicoms.am
Ready