

Visualization in MIPAV

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3D Visualization Outline

- 3D Image Processing
- Volume rendering
- Surface extraction and rendering
- Advanced rendering techniques
- Visualization Applications in MIPAV
 - Diffusion Tensor Visualization, ISO-Surface rendering, virtual endoscopy.

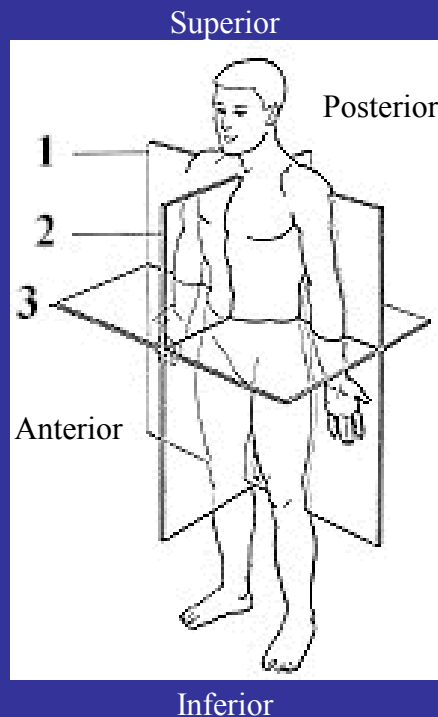


Course Goals

- Know what 3D visualization capabilities are available in MIPAV
- Familiar with the tools and user-interface
- Able to start creating visualizations



A Brief Introduction to 3D Medical Images



Medical images taken of the human body are acquired or displayed in three main orientations:

1. Coronal orientation: in a cross section (plane), for example, across the shoulders, dividing the body into front and back halves

2. Sagittal orientation: in a cross section (plane), for example, down the middle, dividing the body into left and right halves

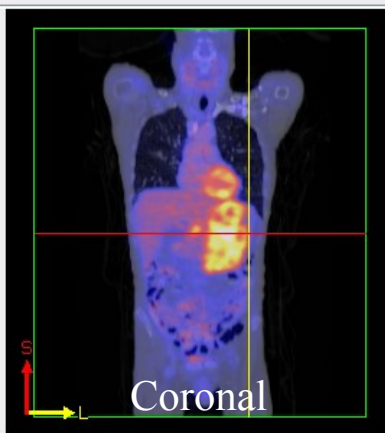
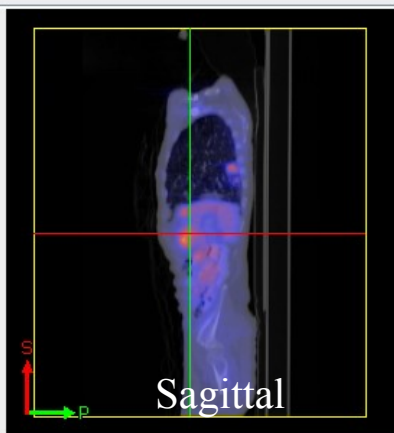
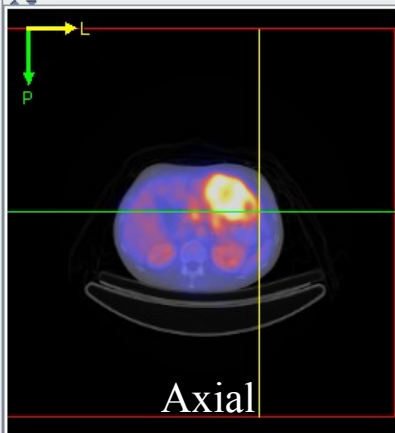
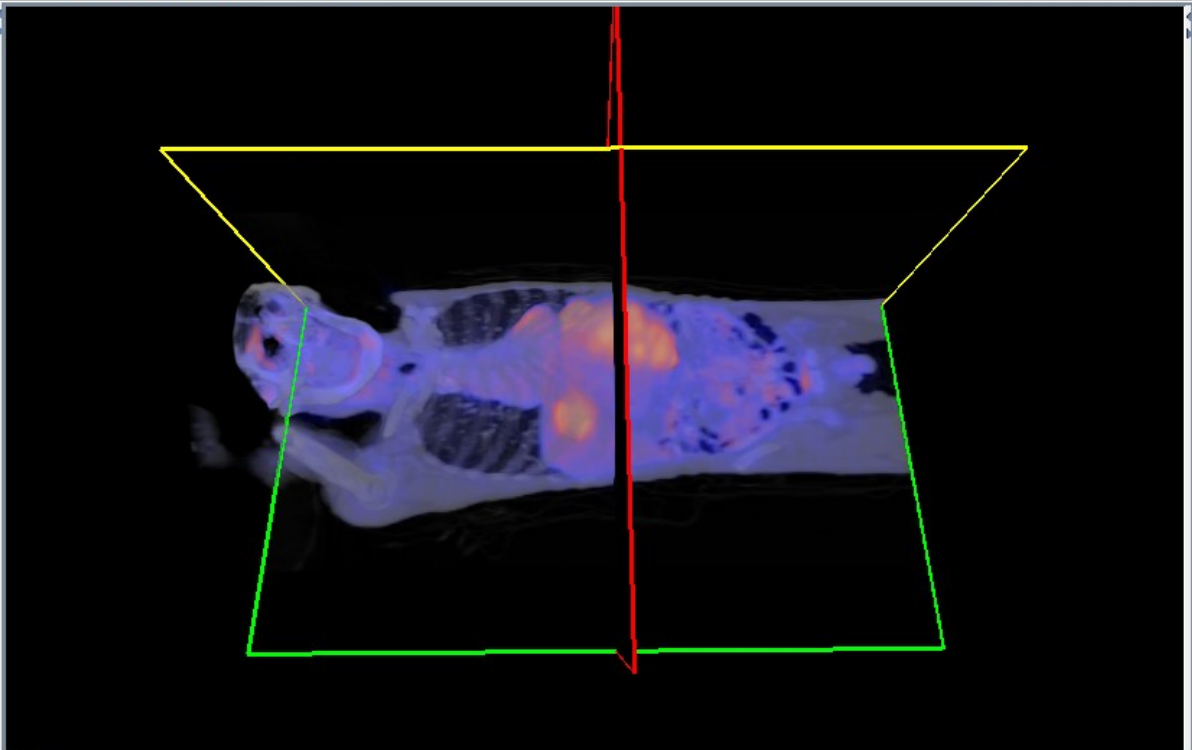
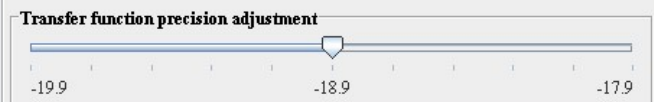
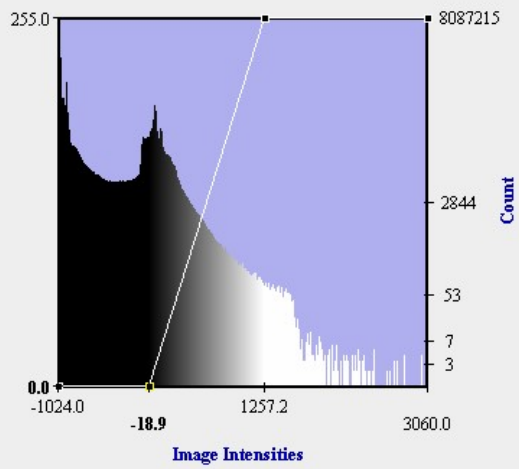
3. Axial orientation: in a cross section (plane), perpendicular to the long axis of the body, dividing the body into upper and lower halves



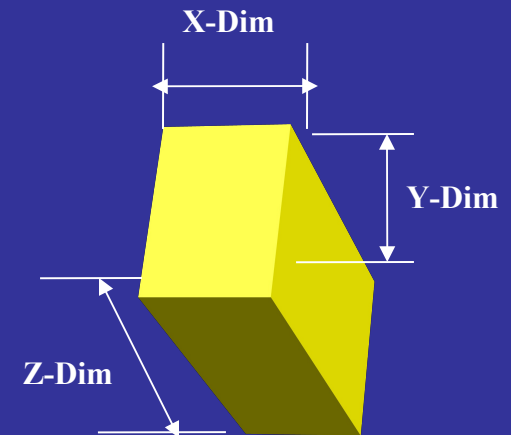
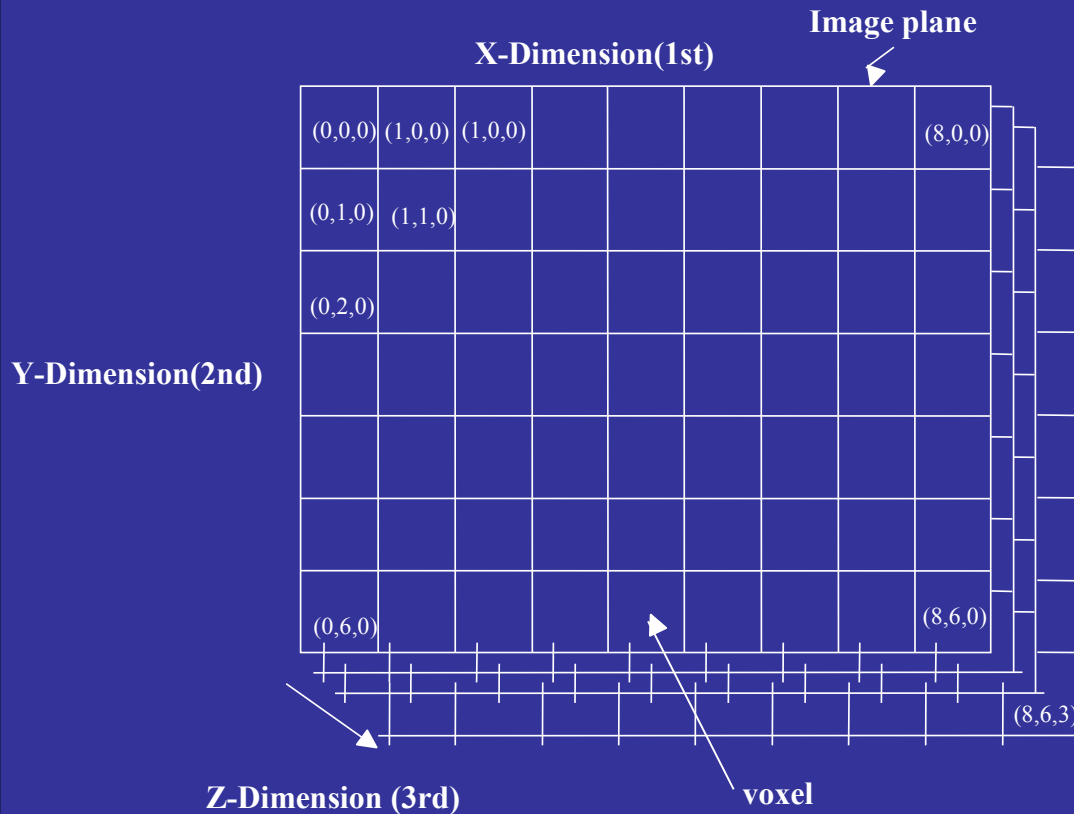


ImgA ImgB

Opacity function for image A



Voxel Thickness & Resolution

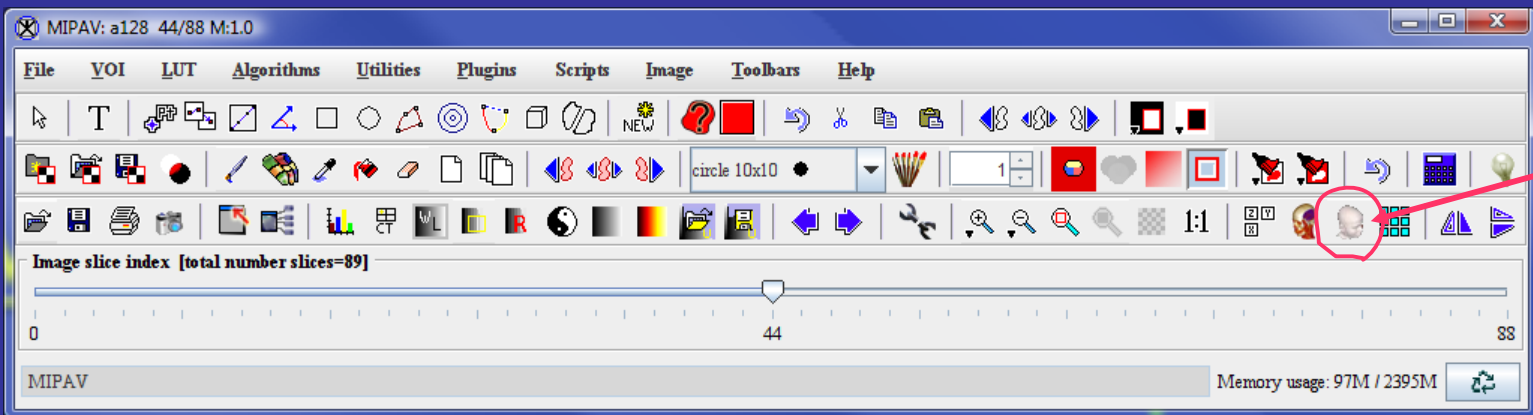


Voxels, of 3D clinical images, are typically NOT isotropic. **This factor should be accounted for in processing algorithms.**

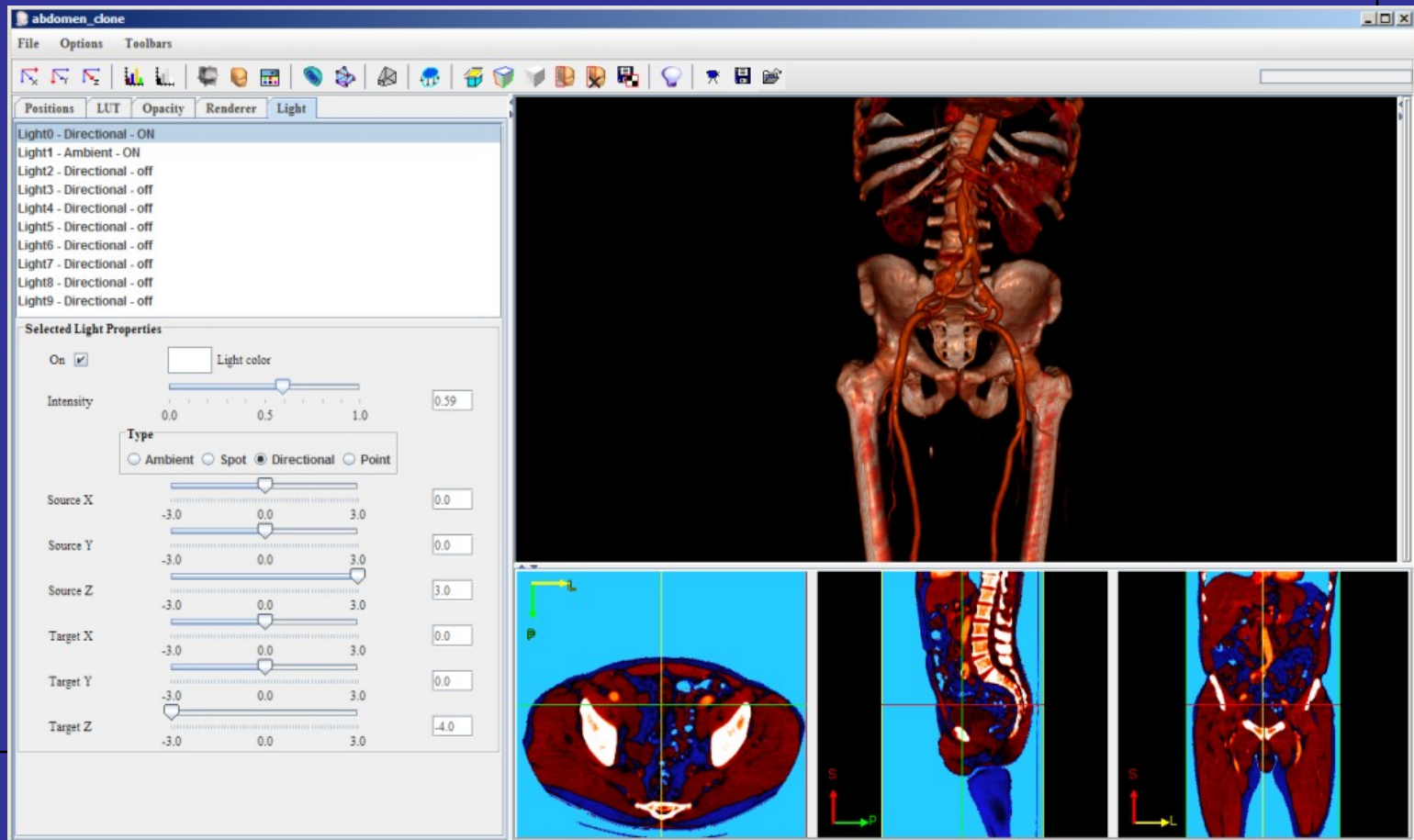


3D Visualization

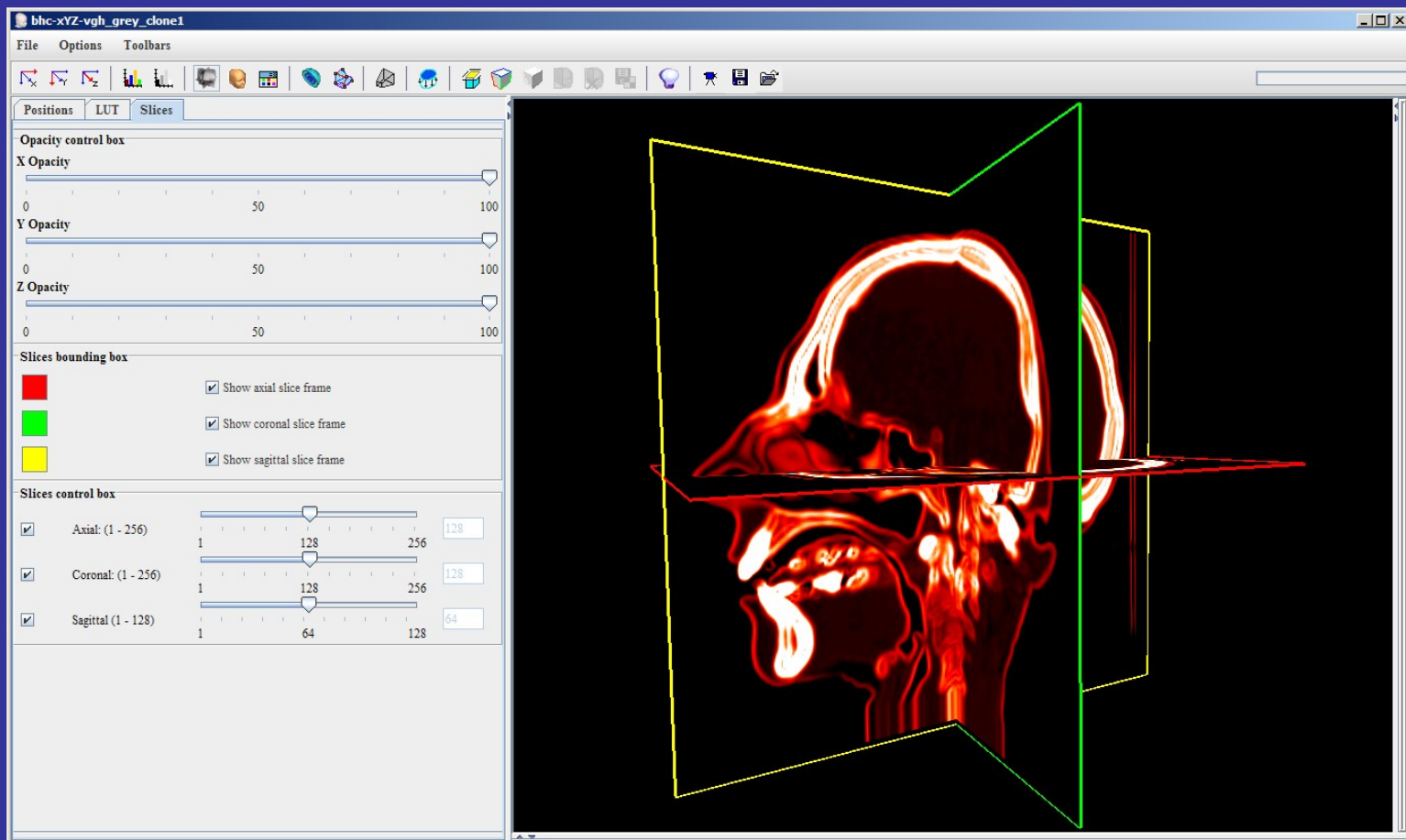




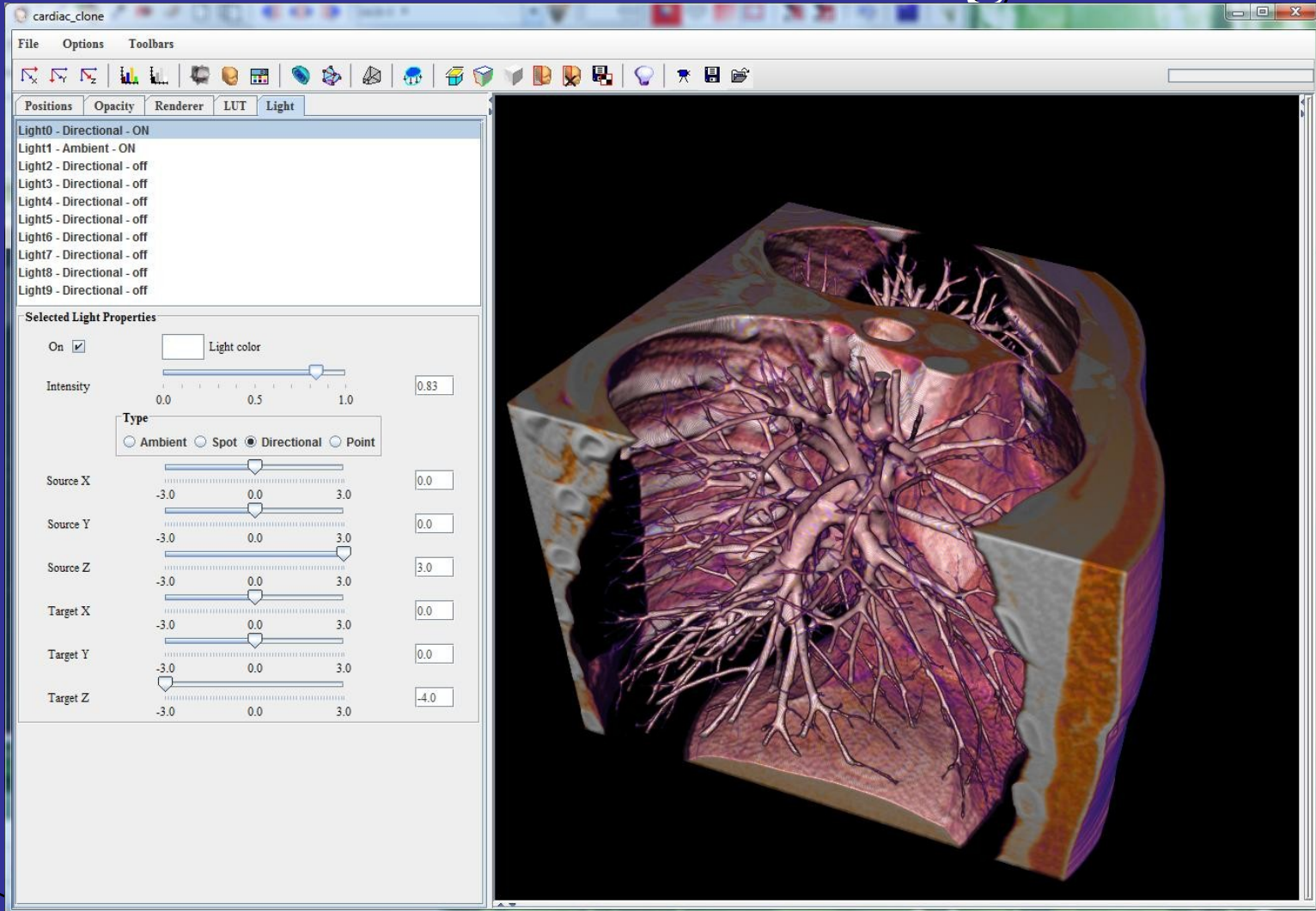
Launch
GPU-Based
Volume Renderer



Orthogonal Plane View



Volume Rendering



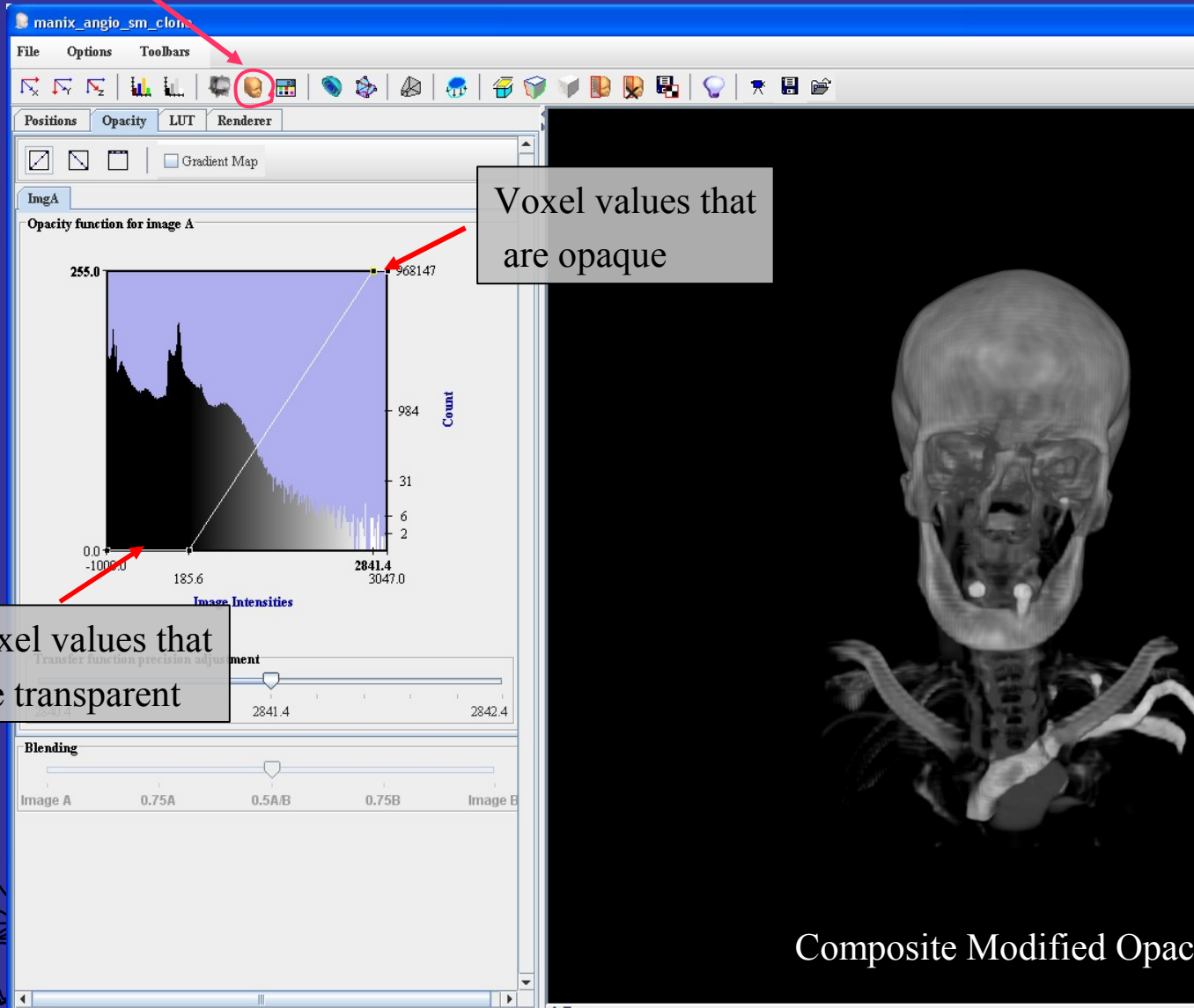
Volume Rendering

- Opacity filter
- Gradient magnitude filter
- Color Lookup Table
- Global opacity and blending
- 2D Histogram filters
- Clipping and Sculpting Volumes



Select Volume View

Opacity Filter



Voxel values that are opaque

Voxel values that are transparent



Composite Modified Opacity



Gradient Magnitude Filter

manix_angio_sm_clone

File Options Toolbars

Positions Opacity LUT **Renderer**

Gradient Map

ImgA **ImgA_GM**

Opacity function for image A gradient magnitude

255.0 1094537

42.0 1046

0.0 32

0.0 335.6 711.3 1023.0

Image Intensities

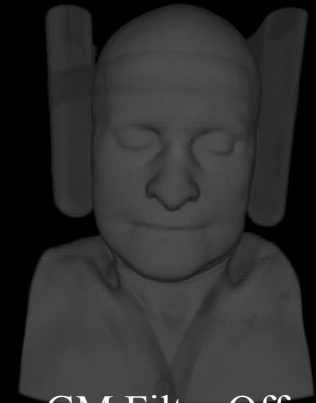
Count

Transfer function precision adjustment

706.3 711.3 716.3

Blending

Image A 0.75A 0.5A/B 0.75B Image B

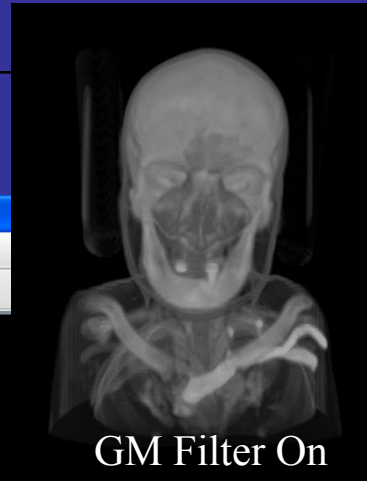


GM Filter Off



Select Color Lookup Table

Adding Color



The screenshot shows a software window titled "manix_angio_sm1" with a menu bar (File, Options, Toolbars) and a toolbar. Below the toolbar are tabs for "Positions", "Opacity", "Renderer", "LUT", and "Display". The "LUT" tab is active, showing a color palette and a histogram. The histogram is titled "Image Intensities" and has a vertical axis labeled "Count" with values 2, 6, 31, 984, and 968147. The horizontal axis has values -1000.0, -381.04, 333.12, and 3047.0. A red arrow points from the "LUT" tab to the histogram. Another red arrow points from a text box to the right edge of the histogram, indicating a value of 255. Below the histogram, there are input fields for "X Range" (333.12) and "Y Range" (255). A slider is visible below the Y Range field.

Voxel values that are white

Voxel values that are black



Volume Rendering Modes

manix_angio_sm1

File Options Toolbars

Positions Opacity **Renderer** LUT Display

Display Components

- Display RayCast Volume
- Display Slices
- Display Surface

Stereo Mode: Off

Render Mode

- MIP
- DRR
- Composite
- Surface
- Composite Surface
- Custom Blend
- MultiHistogram

Blend

- Volume Blend
- Volume Samples Mouse Released
- Volume Samples Mouse Rotation

Surface Extraction

Extract Mesh from Volume Intensity Level 50

Advanced shader parameters

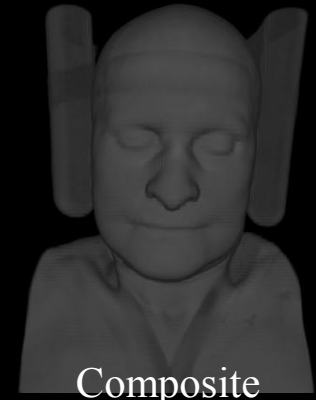
Shader Parameters

Render mode panel

Set render mode



Digitally Reconstructed Radiograph



Composite

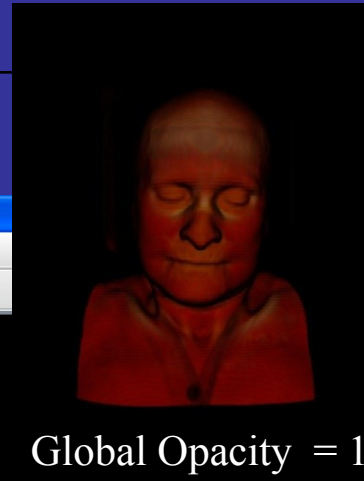


MIP



Surface

Modifying Global Opacity



manix_angio_sm_clone

File Options Toolbars

Positions Opacity LUT Renderer

Display Components

- Display RayCast Volume
- Display Slices
- Display Surface

Stereo Mode: Off

- Self Shadow

Render Mode

- MIP
- DRR
- Composite
- Surface
- Composite Surface
- Custom Blend
- MultiHistogram

Blend

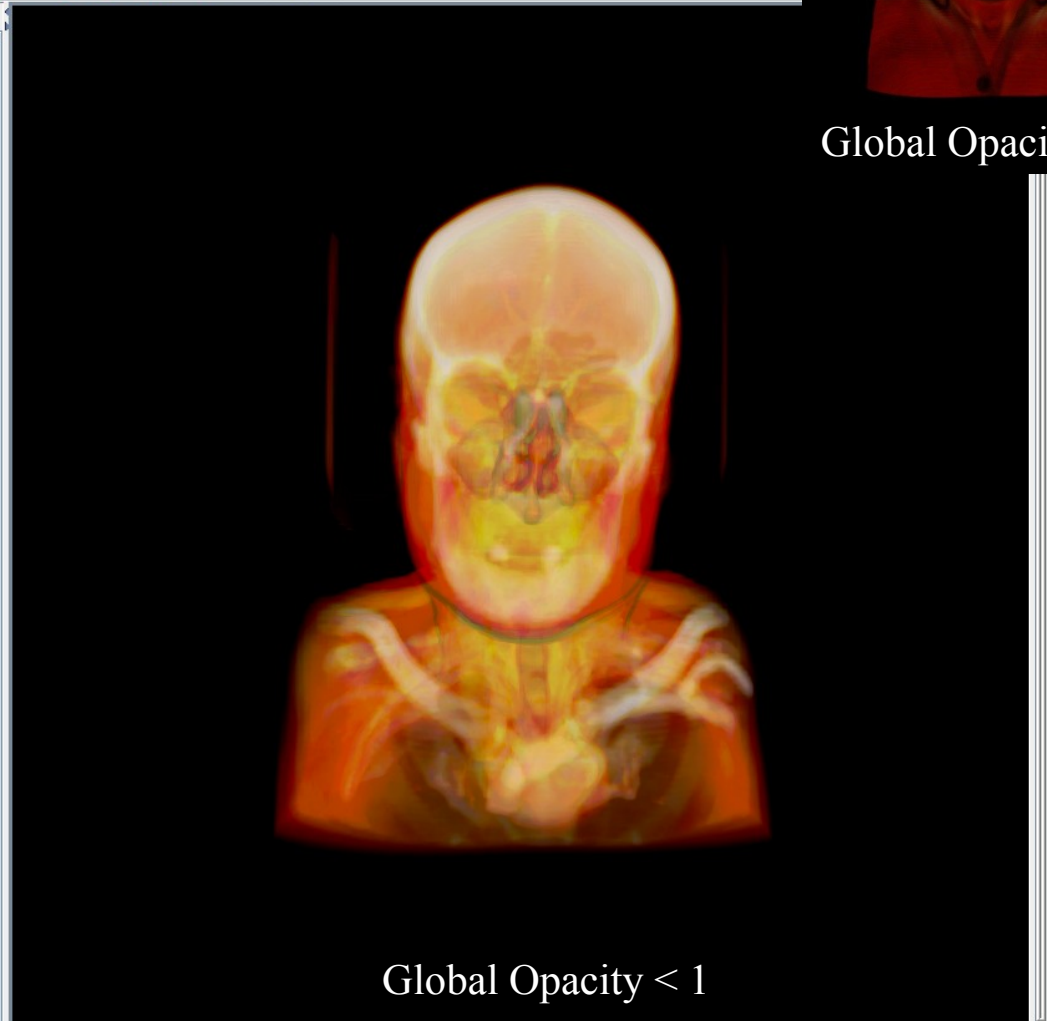
- Volume Blend: [Slider]
- Volume Samples Mouse Released: [Slider]
- Volume Samples Mouse Rotation: [Slider]

Surface Extraction

Extract Mesh from Volume Intensity Level: 50

Advanced shader parameters

Shader Parameters



2D Histogram Tool

manix_angio_sm_clone

File Options Toolbars

Positions Opacity Renderer MultiHistogram

Select Widget Type: Square Triangle

Histogram Constant Color: ■

Histogram opacity:

Boundary Emphasis Slider:

GM Filter On

Two histogram filters

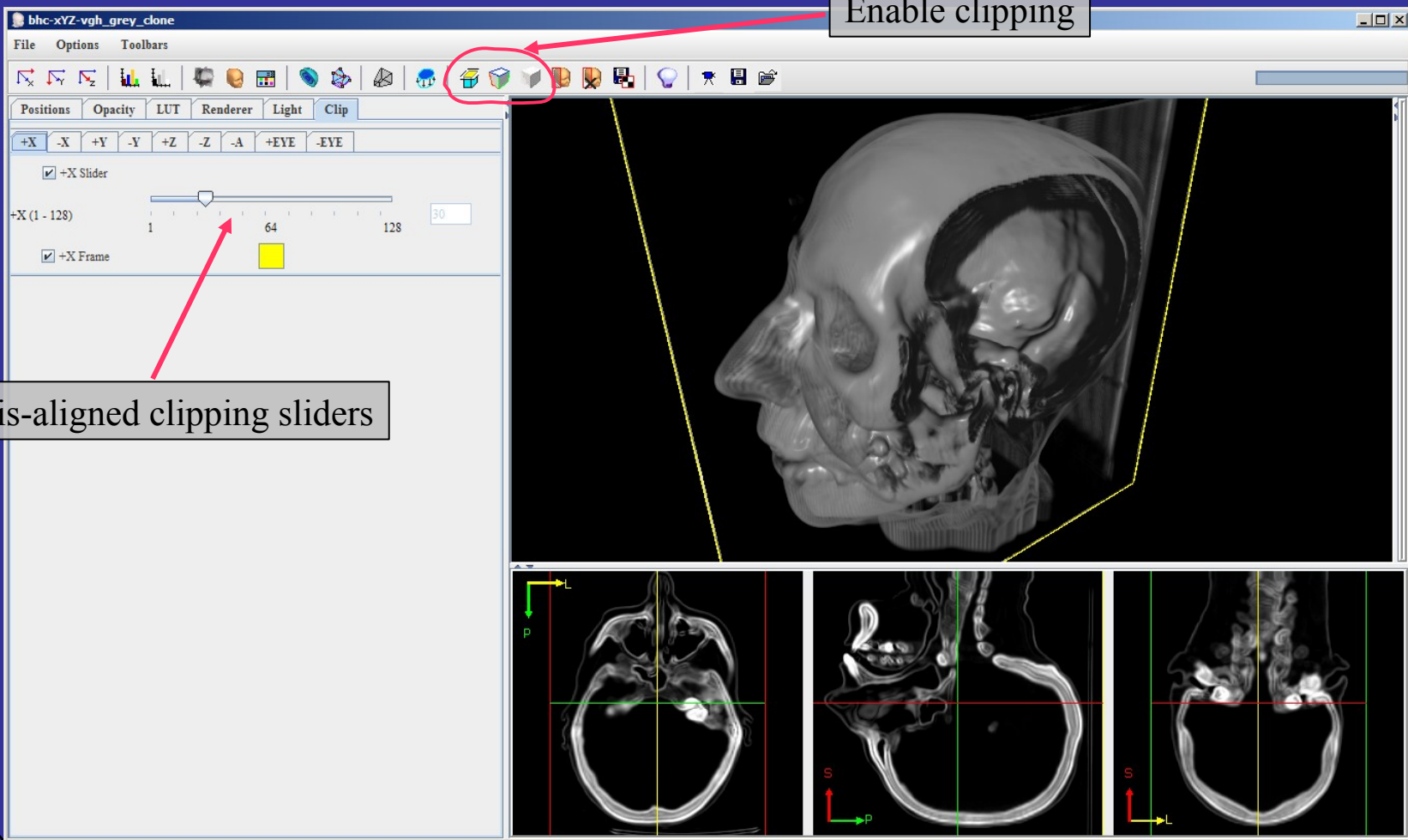


2D Histogram Tool



Volume Clipping

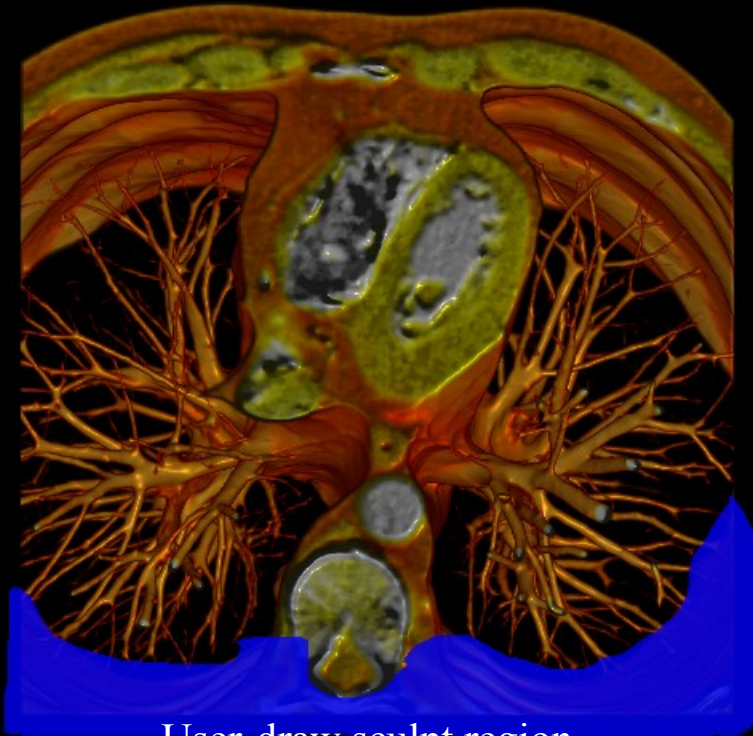
Enable clipping



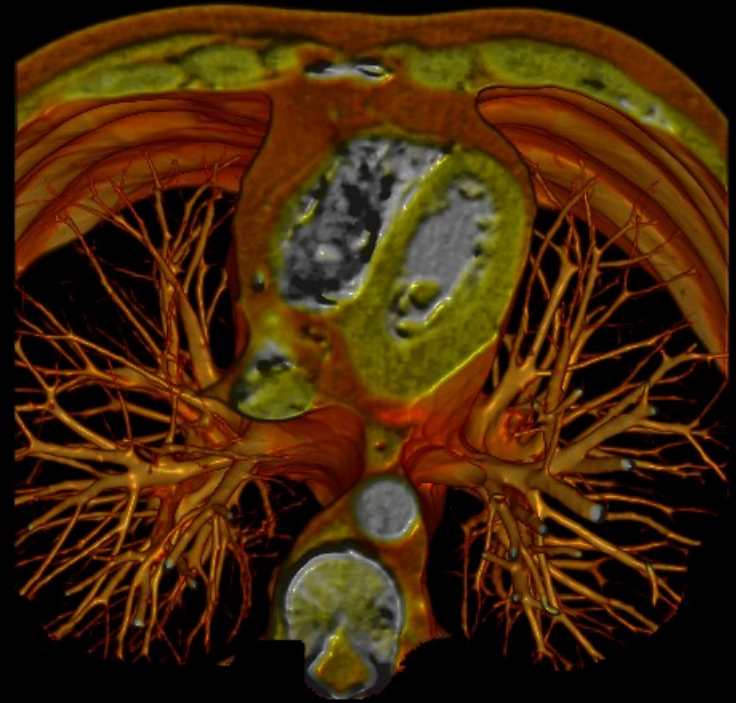
Axis-aligned clipping sliders



Sculpturing Tool



User-draw sculpt region



After volume sculpting



Volume Rendering Demo

- Opacity filter
- Gradient magnitude filter
- Color Lookup Table
- Global opacity and blending
- 2D Histogram filters
- Clipping and Sculpting Volumes

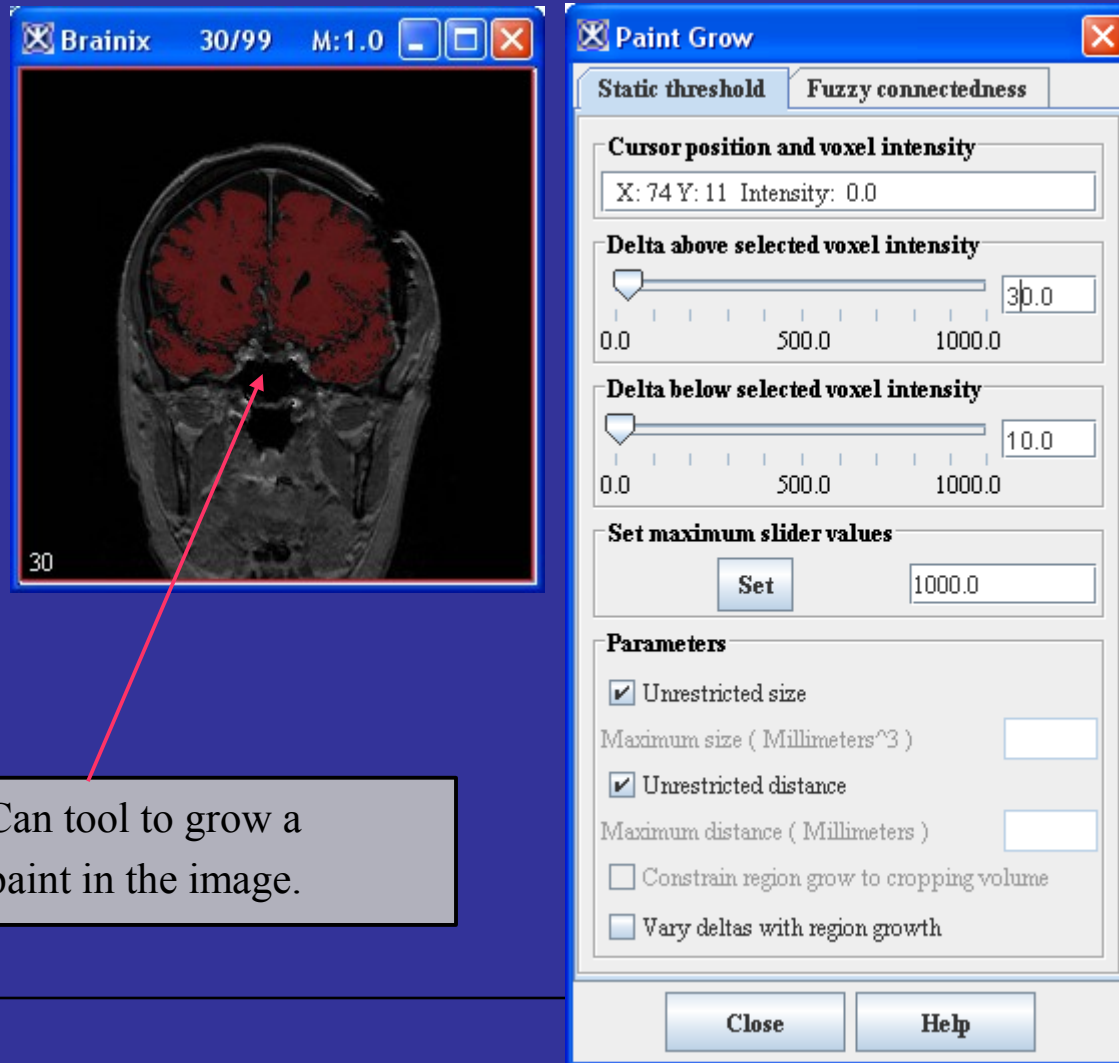


Creating and Rendering Surfaces

- Creating Surfaces
- Adding a surface to the viewer
- Color and material
- Smoothing and decimation
- Painting on surfaces



Surface Extraction from 2D Viewer



The image shows two software windows. The left window, titled "Brainix", displays a coronal MRI slice of a brain with a red region. The right window, titled "Paint Grow", shows settings for static threshold and fuzzy connectedness. The "Paint Grow" window has two tabs: "Static threshold" and "Fuzzy connectedness". The "Fuzzy connectedness" tab is active. It contains the following settings:

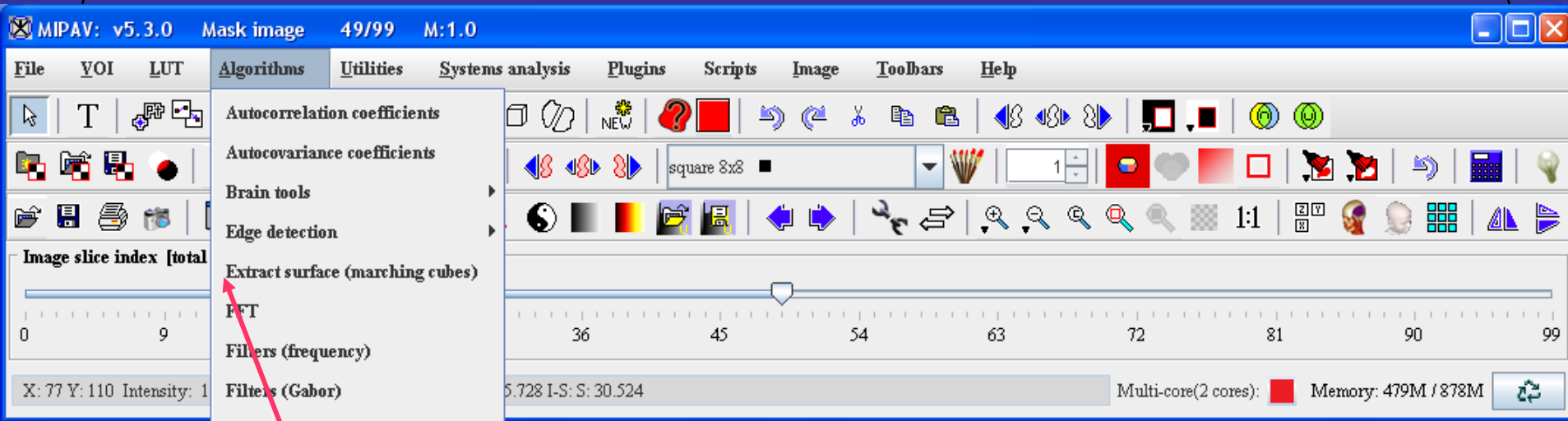
- Cursor position and voxel intensity:** X: 74 Y: 11 Intensity: 0.0
- Delta above selected voxel intensity:** 30.0
- Delta below selected voxel intensity:** 10.0
- Set maximum slider values:** 1000.0
- Parameters:**
 - Unrestricted size
 - Maximum size (Millimeters³)
 - Unrestricted distance
 - Maximum distance (Millimeters)
 - Constrain region grow to cropping volume
 - Vary deltas with region growth

Buttons for "Close" and "Help" are visible at the bottom of the "Paint Grow" window.

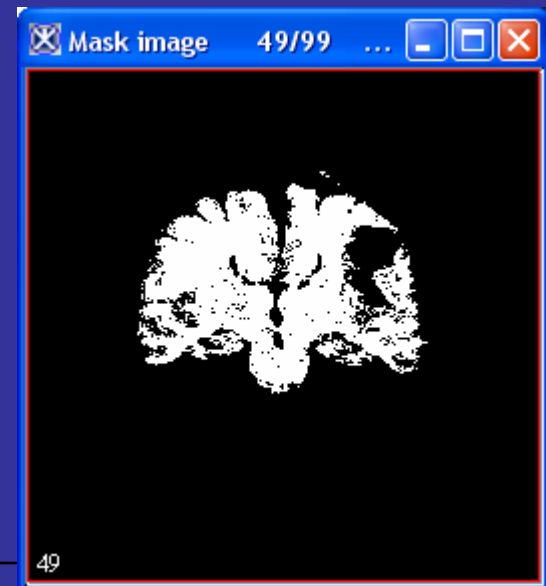
Use the Paint Can tool to grow a 3D region of paint in the image.



Surface Extraction from 2D Viewer



Algorithms -> Extract surface (marching cubes)
Extracts from a mask or VOI region.



WYSIWYG Surface Extraction

manix_angio_sm_clone

File Options Toolbars

Positions Opacity Renderer

Display Components

- Display RayCast Volume
- Display Slices
- Display Surface

Storage Mode Off

Self Shadow

Blend Mode

- Composite
- Surface
- Composite Surface
- Custom Blend
- MultiHistogram

Blend

Volume Blend

Volume Samples Mouse Released

Volume Samples Mouse Rotation

Surface Extraction

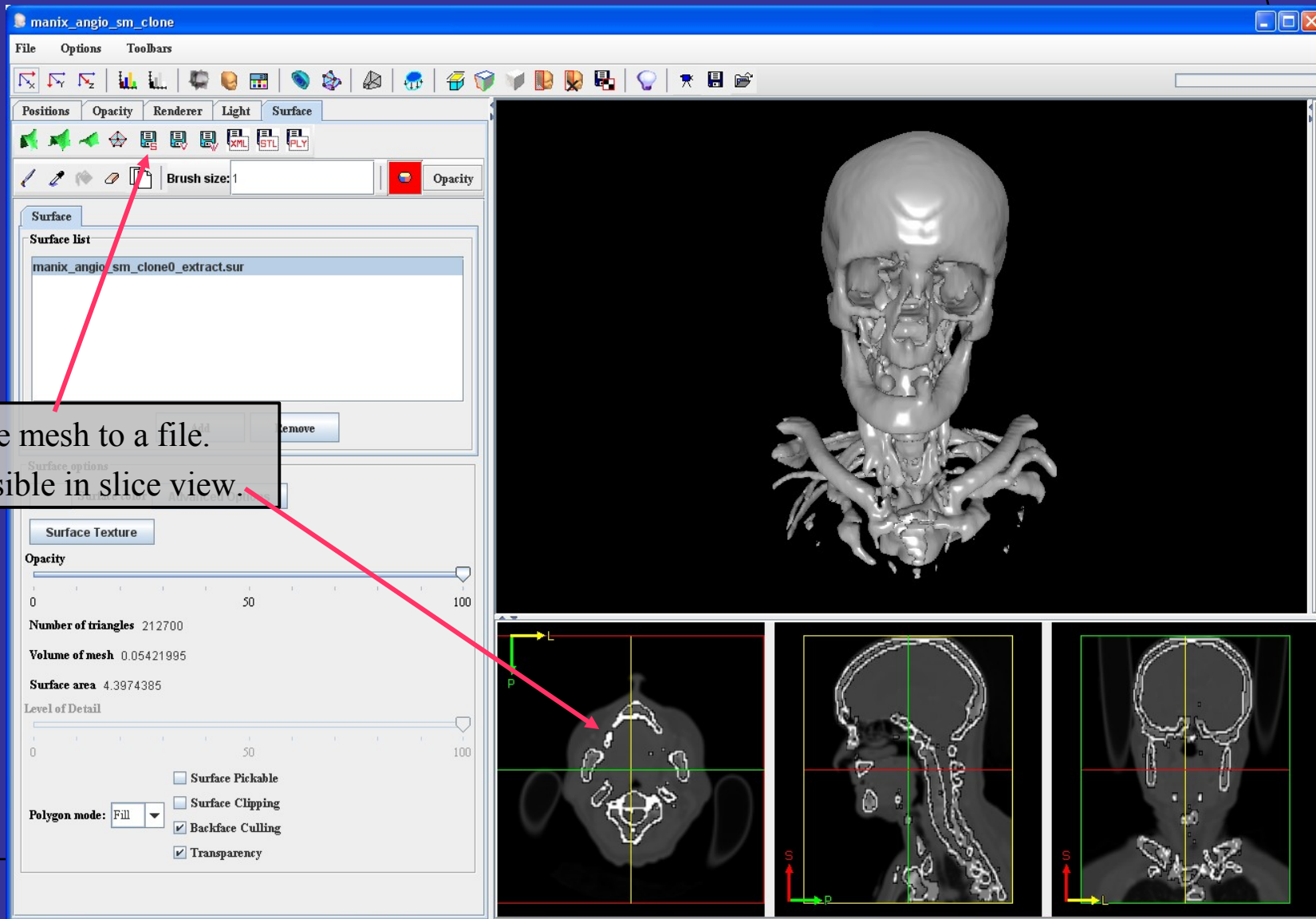
Intensity Level 50

Advanced shader parameters

Adjust the volume opacity.
Display the volume in Surface mode.
Press Extract Mesh Button

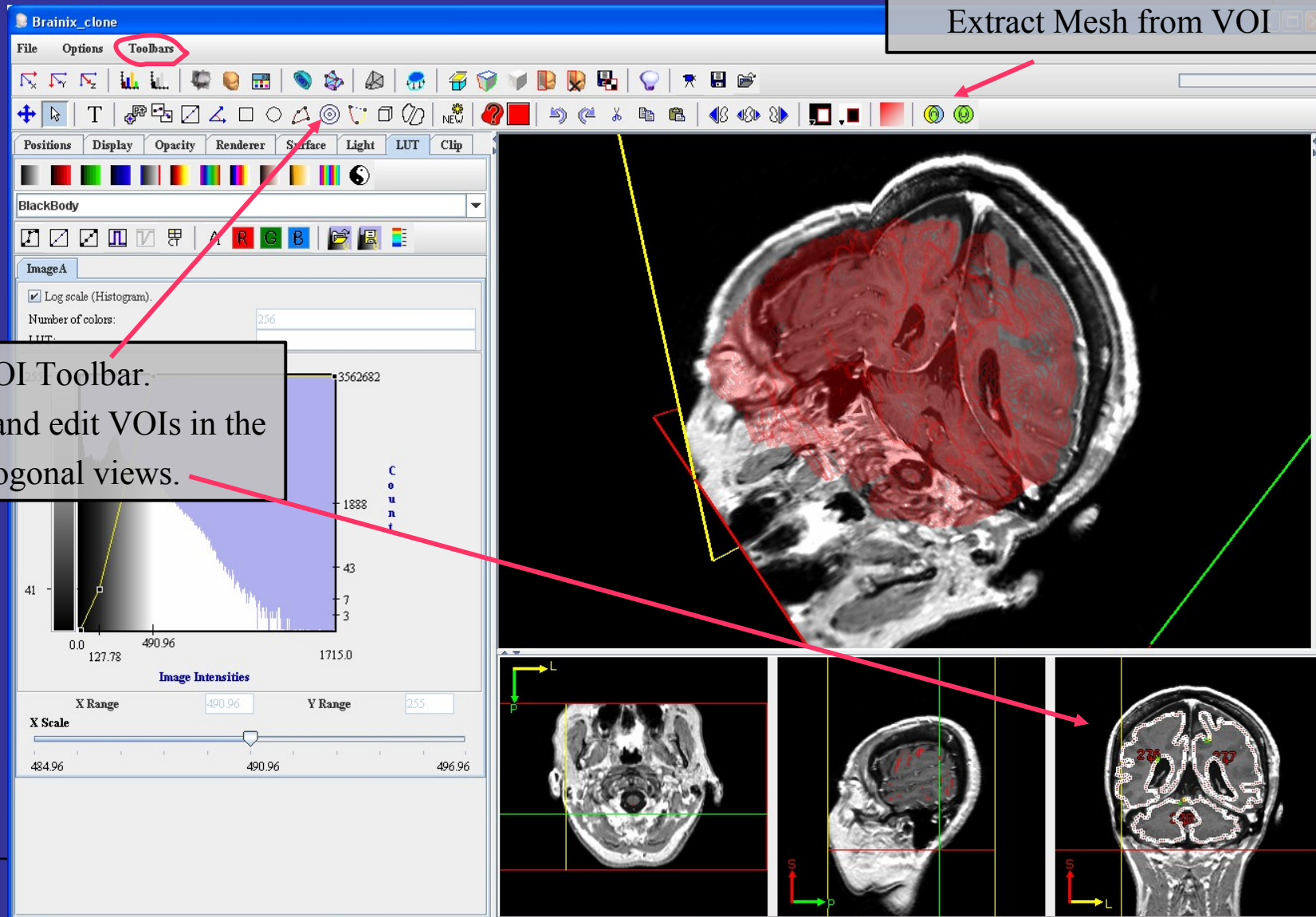


WYSIWYG Surface Extraction



VOI Surface Generation

Extract Mesh from VOI

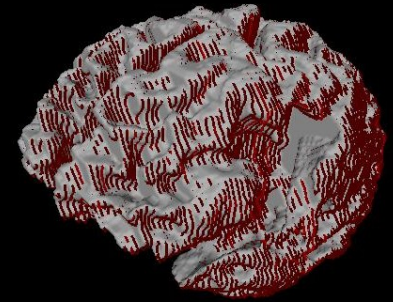


VOI Toolbar.

Can draw and edit VOIs in the orthogonal views.

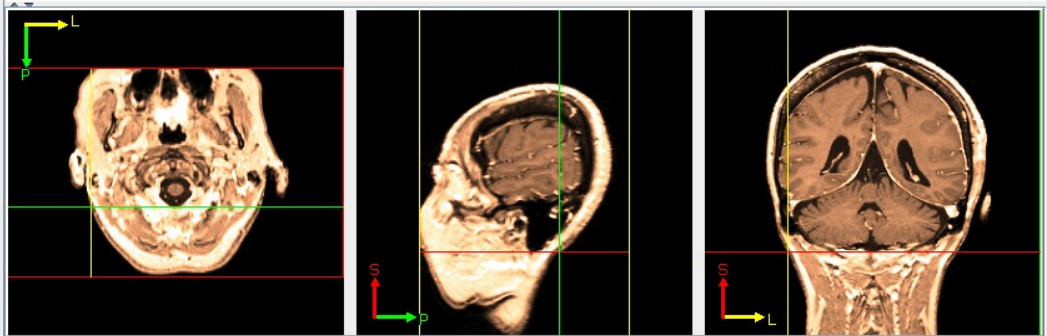
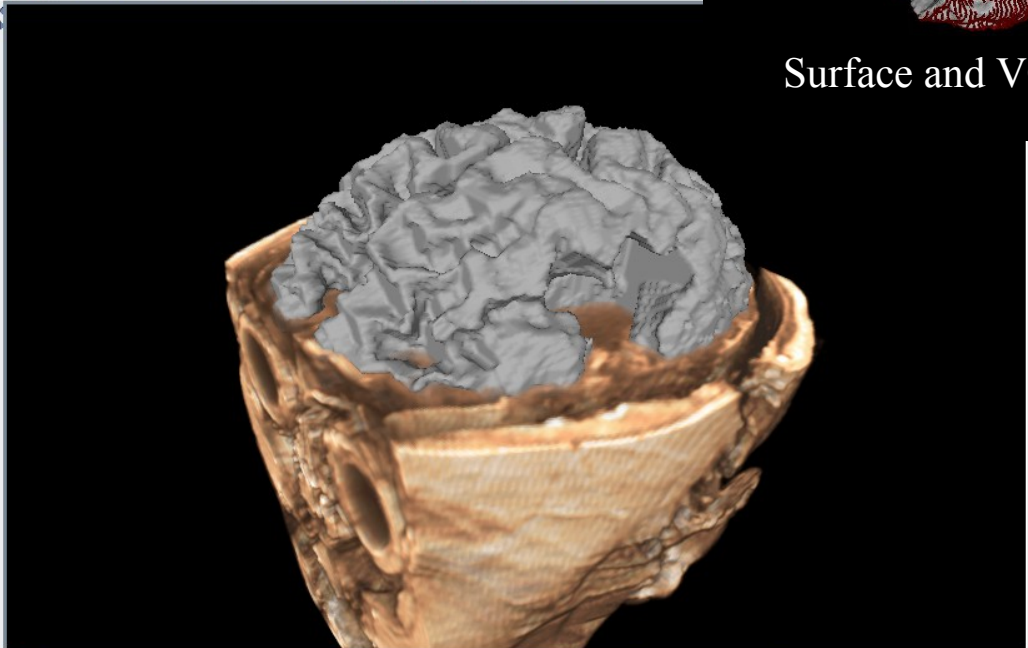


VOI Surface Generation

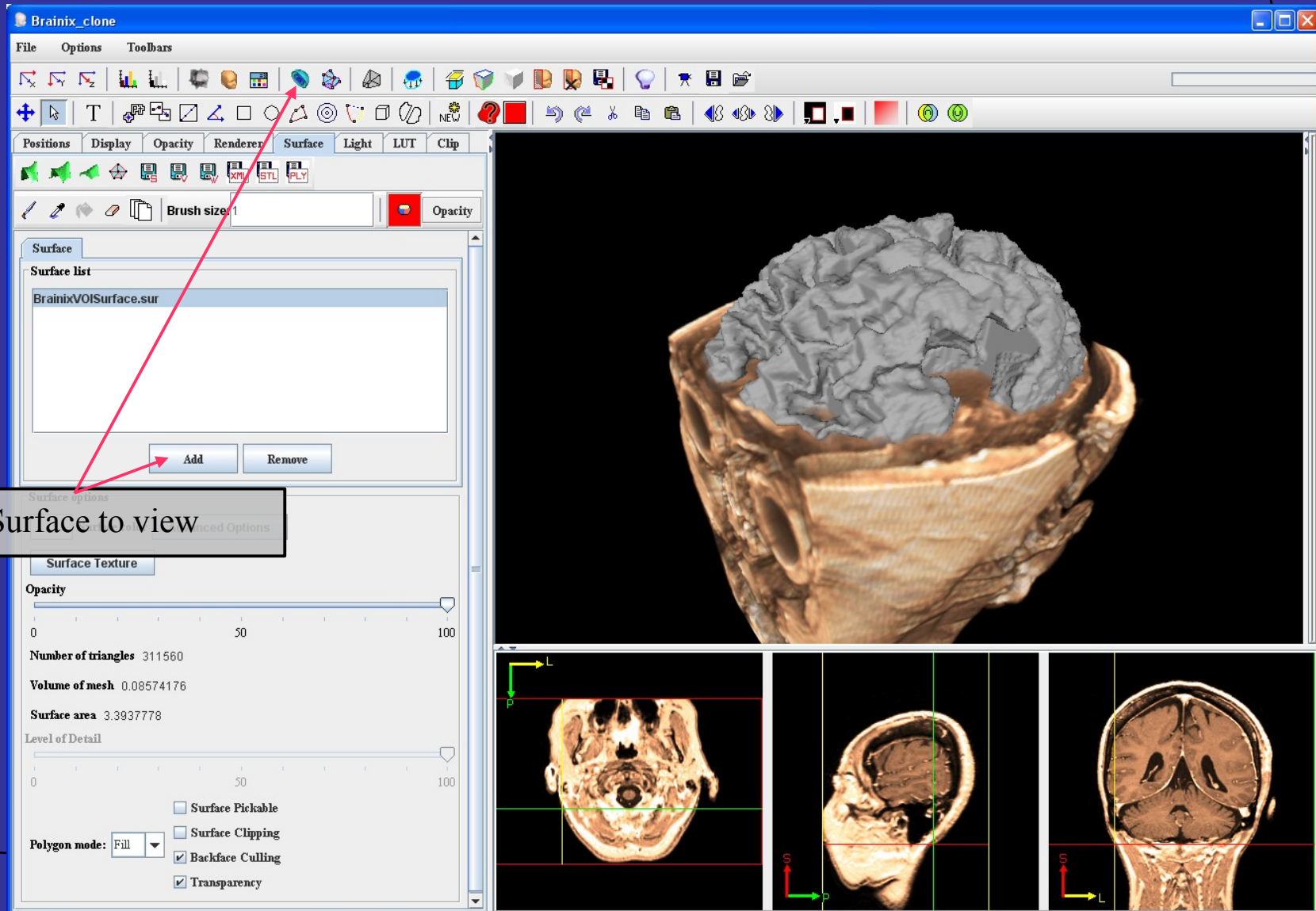


Surface and VOIs

The screenshot shows the Brainix_clone software interface. The main window displays a 3D model of a brain surface, which is a grey mesh resting on a golden, bowl-like structure. The interface includes a menu bar (File, Options, Toolbars), a toolbar with various icons, and several panels. The 'Surface' panel is active, showing a 'Surface list' with 'BrainixVOISurface.sur'. Below this are 'Surface options' including 'Surface color' (set to white), 'Surface Texture', and 'Advanced Options'. A 'Surface options' section contains a slider for 'Opacity' (set to 100) and statistics for 'Number of triangles' (311560), 'Volume of mesh' (0.08574176), and 'Surface area' (3.3937778). A 'Level of Detail' slider is also present. At the bottom, 'Polygon mode' is set to 'Fill', and checkboxes for 'Surface Pickable', 'Surface Clipping', 'Backface Culling', and 'Transparency' are visible.



Adding a Surface from File



Add Surface to view



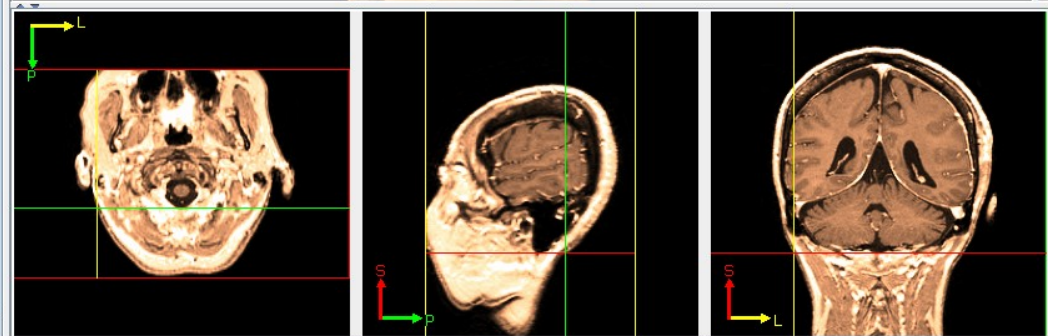
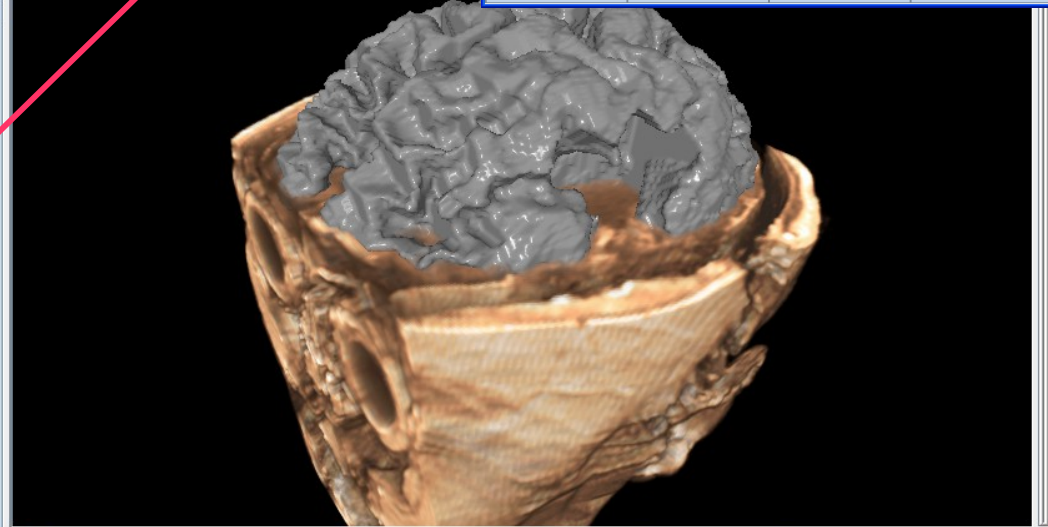
Smooth Surface and Surface Decimation

The screenshot shows the Brainix software interface with the following elements:

- File**, **Options**, **Toolbars** menu bar.
- Positions**, **Display**, **Opacity**, **Renderer**, **Surface**, **Light**, **LUT**, **Clip** tabs.
- Surface list** containing **BrainixVOISurface.sur** with **Add** and **Remove** buttons.
- Surface options** section with **Surface color** and **Advanced Options** buttons.
- Surface Texture** button.
- Opacity** slider from 0 to 100.
- Number of triangles**: 311560
- Volume of mesh**: 0.08574176
- Polygon mode** dropdown set to **Fill**.
- Checkboxes for **Surface Pickable**, **Surface Clipping**, **Backface Culling**, and **Transparency**.

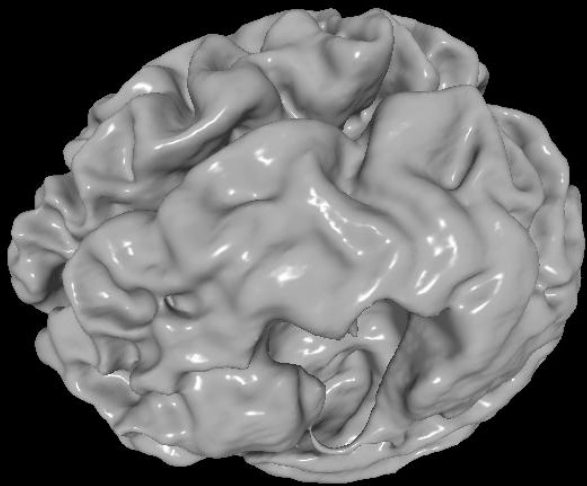
The **Advanced Material Properties** dialog box includes:

- Before** and **After** material preview spheres.
- Preset 0** through **Preset 5** buttons.
- Ambient Color** and **Diffuse Color** fields.
- Specular Color** and **Emissive Color** fields.
- Shininess** slider with values: 1, 17, 33, 49, 65, 81, 97, 113.
- Apply**, **Reset**, **OK**, and **Cancel** buttons.



Solid, line, or point





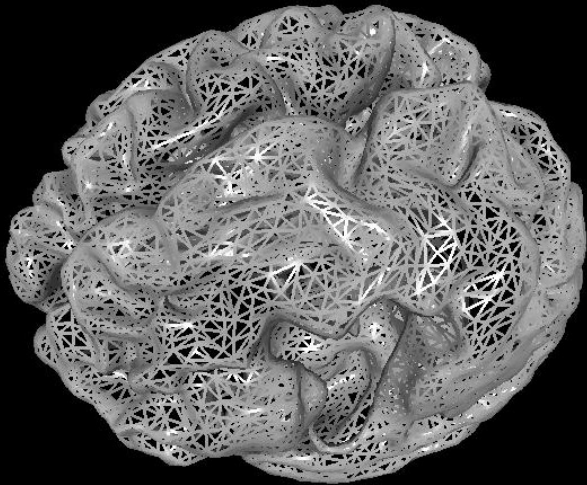
Surface after smoothing.

Add Remove

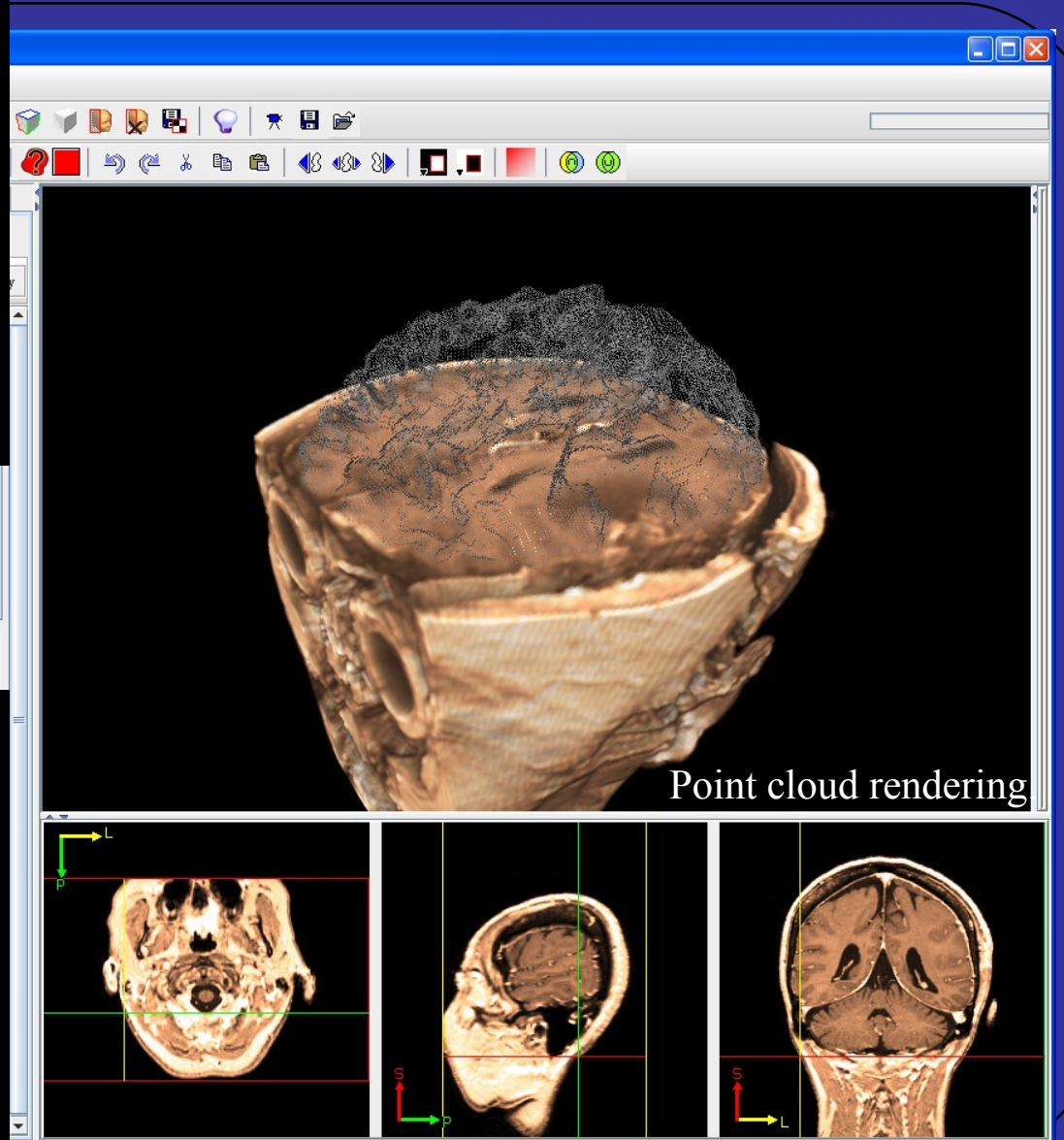
Surface options

Surface color

Advanced Options



Surface after decimation.



Point cloud rendering

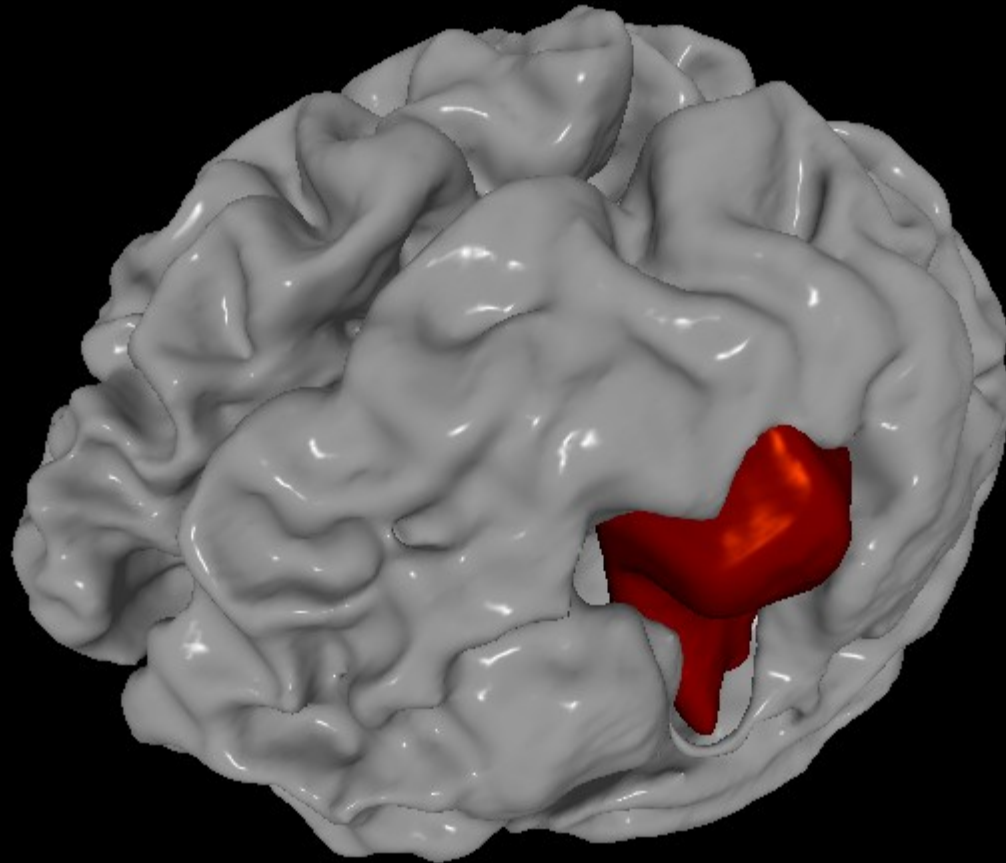
Painting on Surface

The screenshot displays the Brainix_clone software interface. The main window shows a 3D brain model with cyan and blue painted regions. The interface includes a menu bar (File, Options, Toolbars), a toolbar with various icons, and a panel on the left with the following sections:

- Surface list:** Contains the entry "BrainixVOISurface.sur" with "Add" and "Remove" buttons.
- Surface options:** Includes "Surface color" (with a color picker), "Advanced Options", "Surface Texture", and an "Opacity" slider (set to 100).
- Statistics:** Shows "Number of triangles 0", "Volume of mesh 0.0", and "Surface area 0.0".
- Level of Detail:** Includes a slider (set to 50) and checkboxes for "Surface Pickable" (checked and circled in red), "Surface Clipping", "Backface Culling", and "Transparency".
- Polygon mode:** Set to "Fill".

At the bottom, three orthogonal views (axial, sagittal, and coronal) of the brain model are shown, with white outlines indicating the painted regions. A small logo is visible in the bottom-left corner, and the letters "IT" are in the bottom-right corner.

Multiple Surfaces



Brain tumor extracted separately.



Creating and Rendering Surfaces

- Creating Surfaces
- Adding a surface to the viewer
- Color and material
- Smoothing and decimation
- Painting on surfaces



Saving Visualization Data

Record Animation
Save current parameters

The screenshot displays a software window titled "cardiac_sm_clone" with a menu bar (File, Options, Toolbars) and a toolbar. The toolbar contains various icons, with a red circle highlighting the "Record Animation" (a blue camera icon) and "Save current parameters" (a floppy disk icon) buttons. The main view area shows a 3D visualization of a heart and its branching vessels, rendered in a golden-yellow color. Below the main view, there are three smaller panels showing different views of the heart: a coronal view on the left, a sagittal view in the middle, and a transverse view on the right. On the left side of the interface, there is a "Positions" panel with a color palette and a "Renderer" panel with a "BlackBody" dropdown. Below these is an "ImageA" panel with a checked "Log scale (Histogram)" option, a "Number of colors" field set to 256, and a "LUT" field. A histogram titled "Image Intensities" is displayed, showing a distribution of pixel intensities. The histogram's x-axis is labeled "Image Intensities" and has values -1024.0, -787.29, 206.87, 427.79, and 3000.0. The y-axis is labeled "Count" and has values 0, 2, 6, 33, 1064, and 1131401. Below the histogram, there are "X Range" and "Y Range" fields, and an "X Scale" slider.

Advanced 3D Visualization

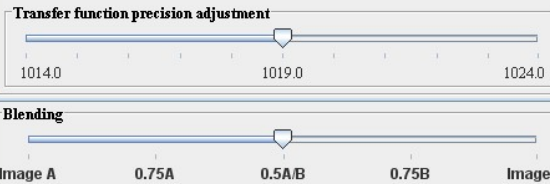
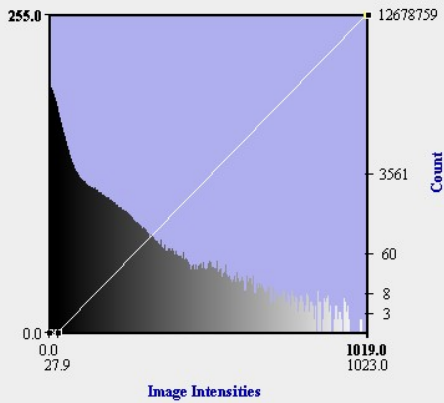
- Image Fusion
- 4D Volume Rendering
- 3D Stereo viewing



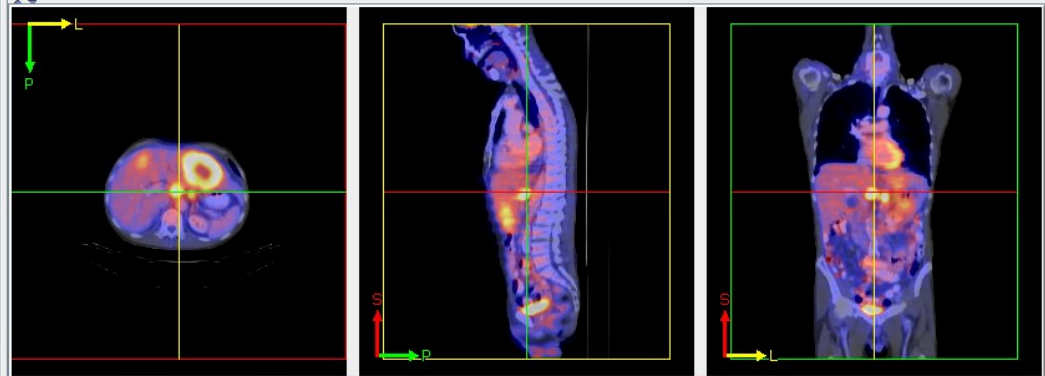
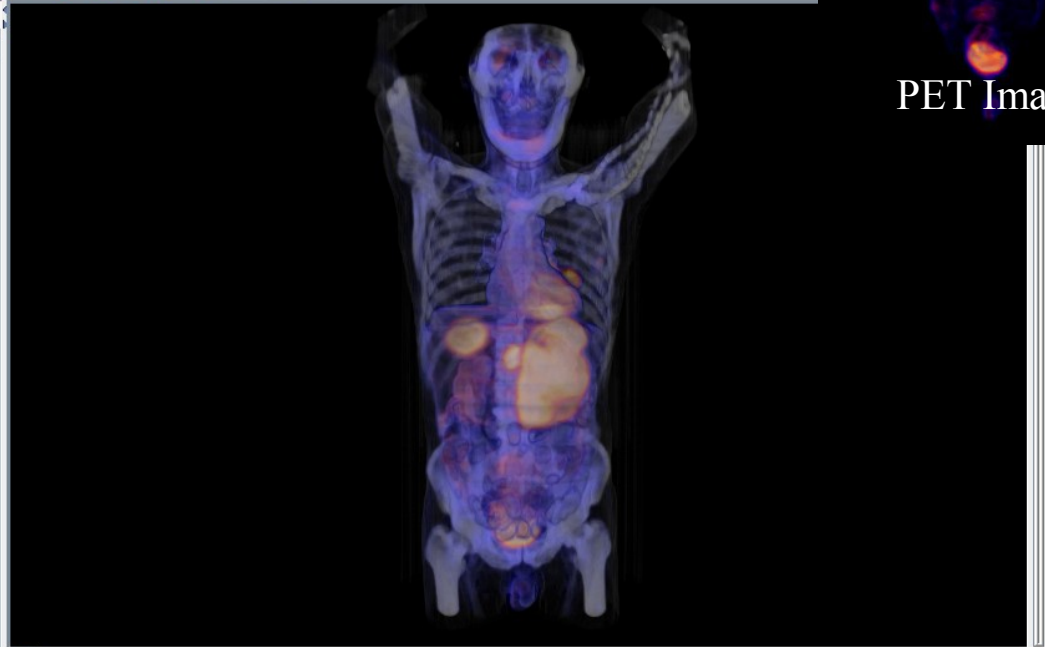
Image Fusion

CT Image A

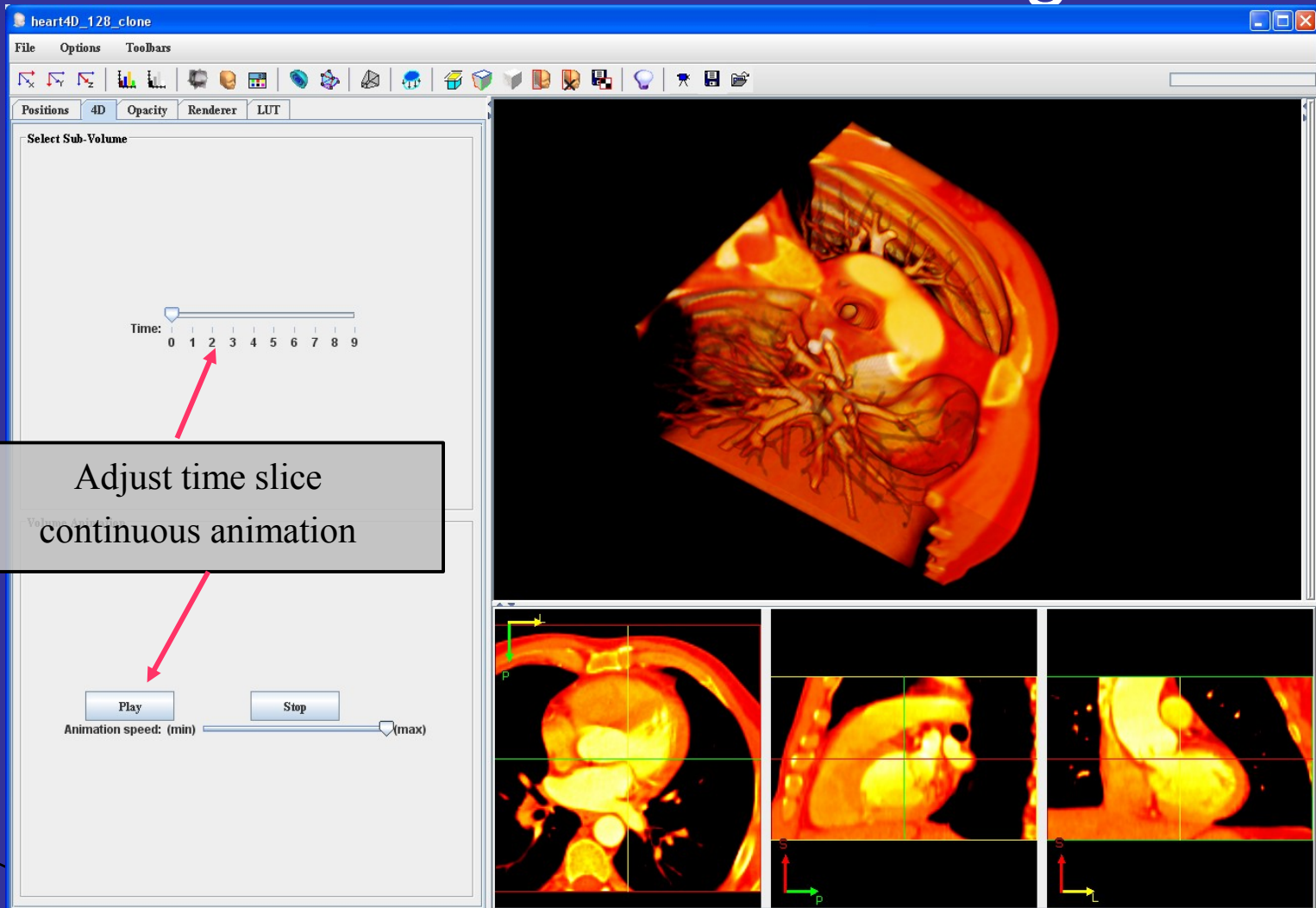
PET Image B



Blend between images.



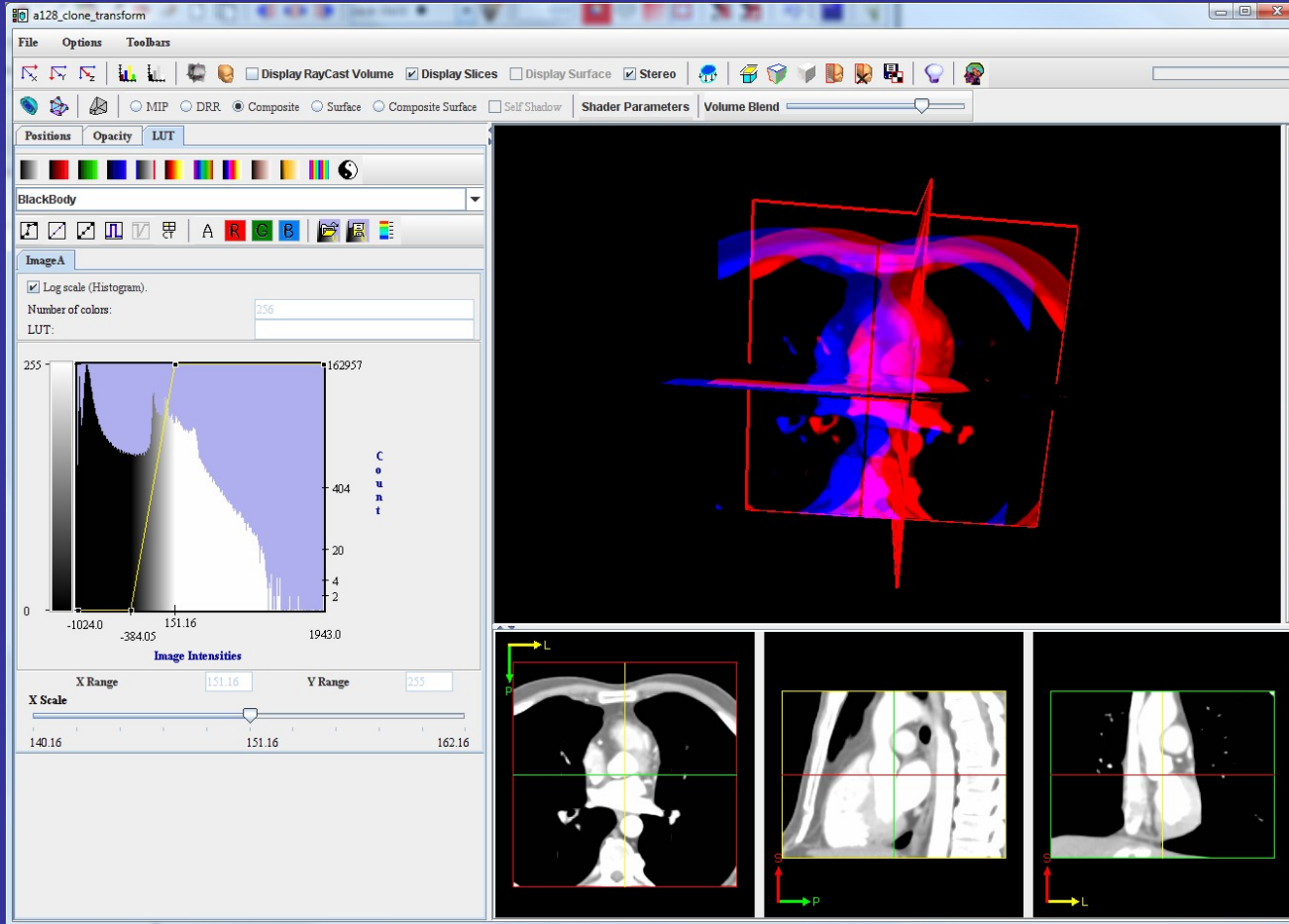
4D Volume Rendering



Adjust time slice
continuous animation



Stereo View



Applications of MIPAV 3D Visualization



DTI Visualization

The image shows a software window titled "BlankImage" with a menu bar (File, Options, Toolbars) and a toolbar. The main interface is divided into a control panel on the left and a visualization area on the right.

Control Panel:

- Display Options:** Display RayCast Volume, Display Slices, Display Surface, Stereo.
- Rendering Mode:** MIP, DRR, Composite, Surface, Composite Surface.
- Other Options:** Self Shadow, **Shader Parameters**, **Volume Blend** (slider).
- DTI / DTI** (selected), **Fibers**, **Slices**, **Light**.
- Opacity control box:** Sliders for X Opacity, Y Opacity, and Z Opacity, each ranging from 0 to 100.
- Slices bounding box:** Show axial slice frame, Show coronal slice frame, Show sagittal slice frame.
- Slices control box:** Axial (1 - 128) [Slider: 1 to 128, value 64], Coronal (1 - 128) [Slider: 1 to 128, value 64], Sagittal (1 - 128) [Slider: 1 to 128, value 64].

Visualization Area:

- Top: 3D visualization of a fiber bundle with various colored fibers (blue, purple, green, yellow, orange, red, pink) extending from a central point.
- Bottom: Three 2D slice views (Axial, Coronal, Sagittal) showing the fiber bundle in cross-section. Each slice has a coordinate system (X, Y, Z) and a bounding box.



DTI Visualization

BlankImage

File Options Toolbars

DWI/DTI Fibers Light Surface Slices LUT

Load Fiber Tracts

Maximum number of tracts to display: 100
Minimum tract length: 50
Maximum tract length: 100
DTI tract file: C:\dti_images\DTIOutput\DTIImage.xml_tract **Load**

Inclusion & Exclusion Parameters

3D VOI list

VOI_0
VOI_1

Include Exclude Ignore

Use VOI
Ctrl and left mouse press to select the individual tract.

Vector component-wise negation

+/- x +/- y +/- z

Fiber Bundle list

FiberBundle100

Add Remove

Fiber bundle options

Fiber Bundle color Use volume color
Display ellipsoids every X step: [slider]
Glyphs & Streamlines
 Lines Ellipsoids Cylinders Tubes Arrows Display All

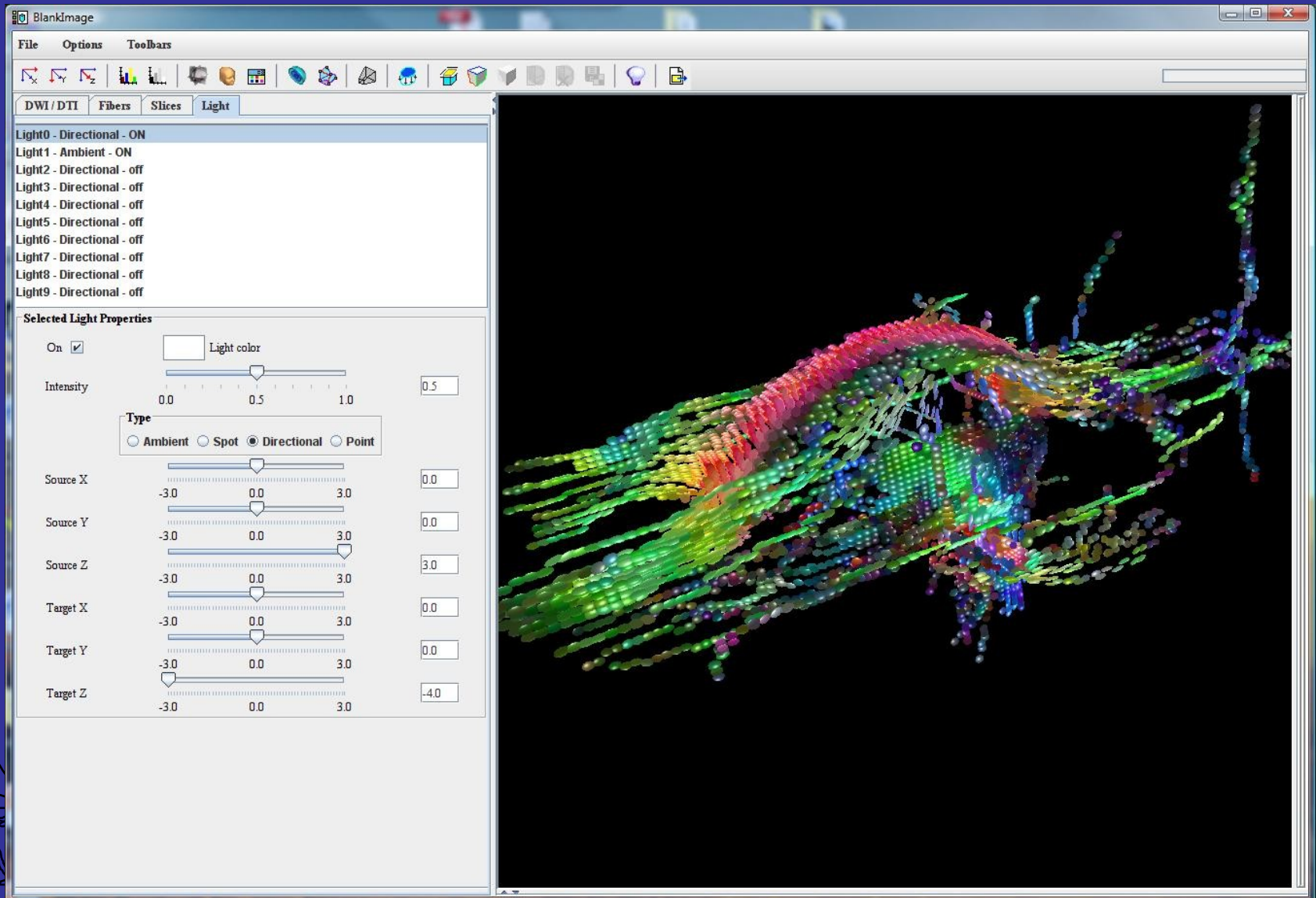
make 3D-VOI Intersection make 3D-VOI Union

3D visualization of fiber tracts in a brain slice, showing a green rectangular volume of interest (VOI) overlaid on the tracts.

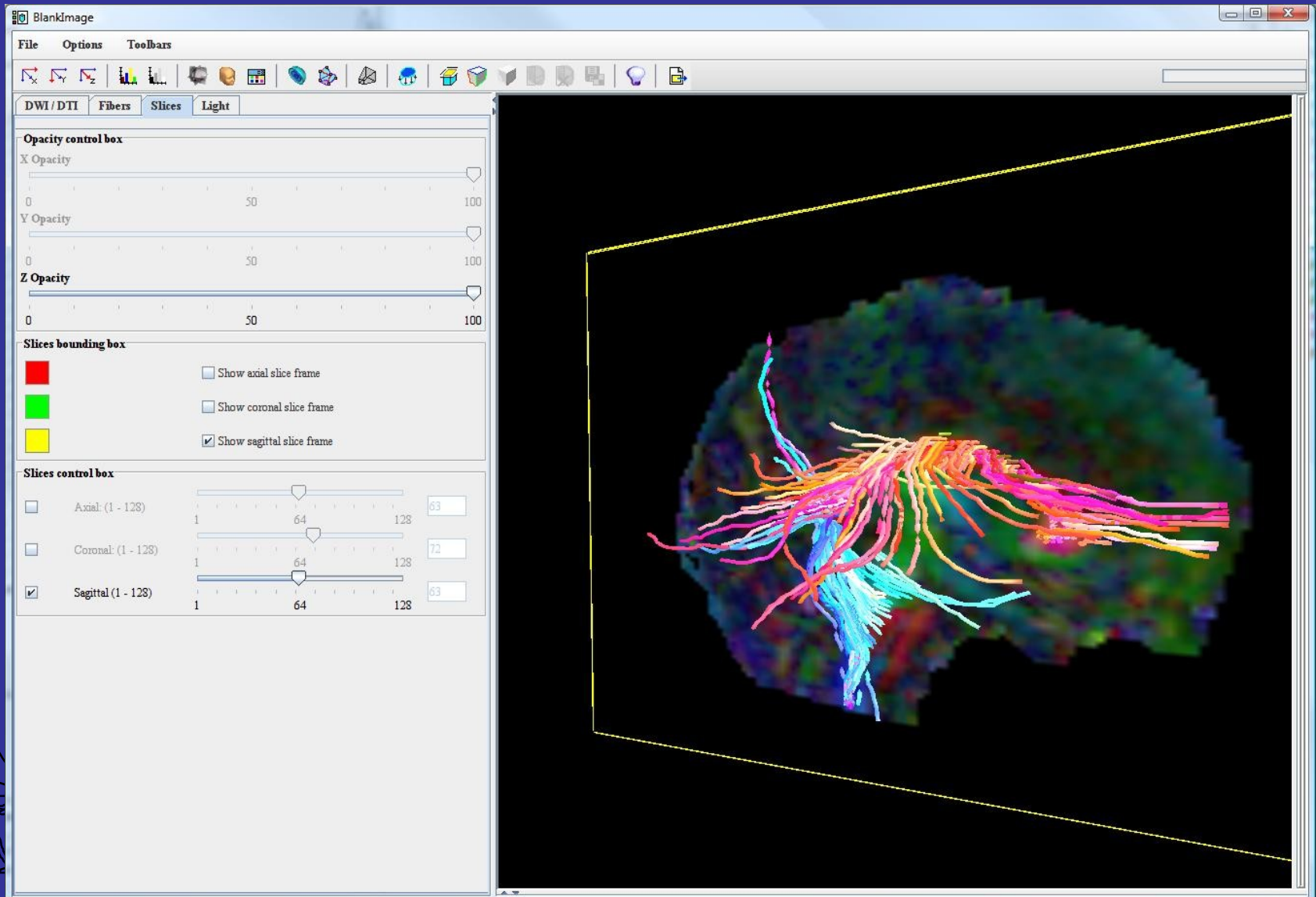
Three orthogonal views (axial, sagittal, and coronal) of the brain slice, showing the fiber tracts and the VOI in different planes.



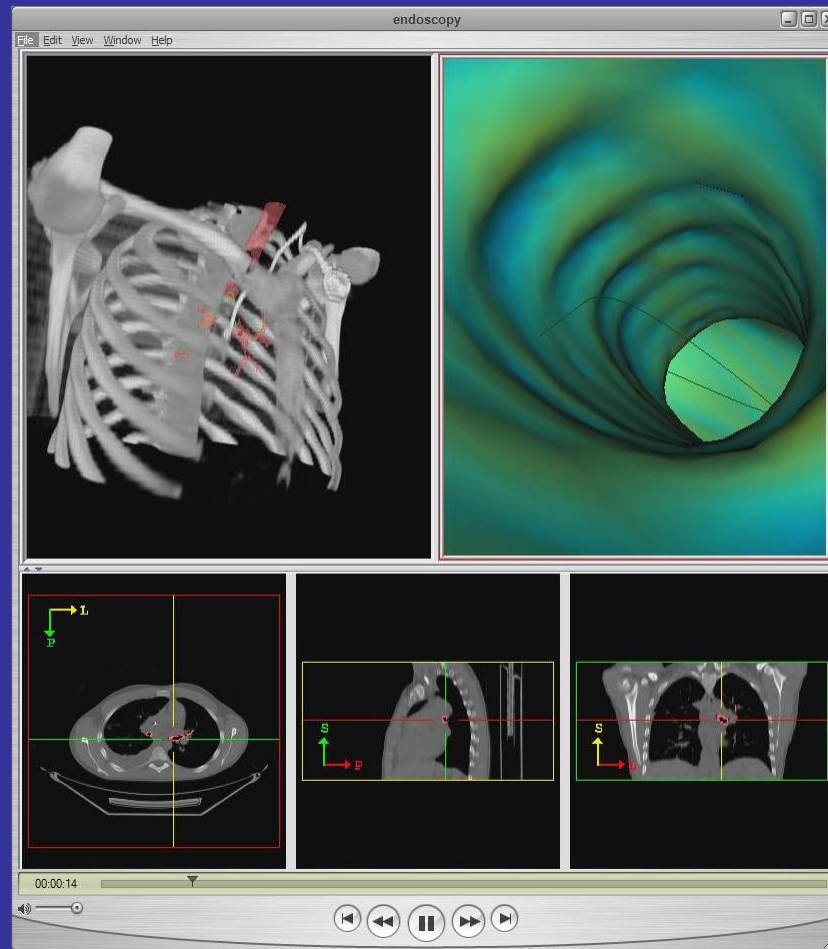
DTI Visualization



DTI Visualization



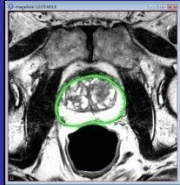
Visual Endoscopy Simulation



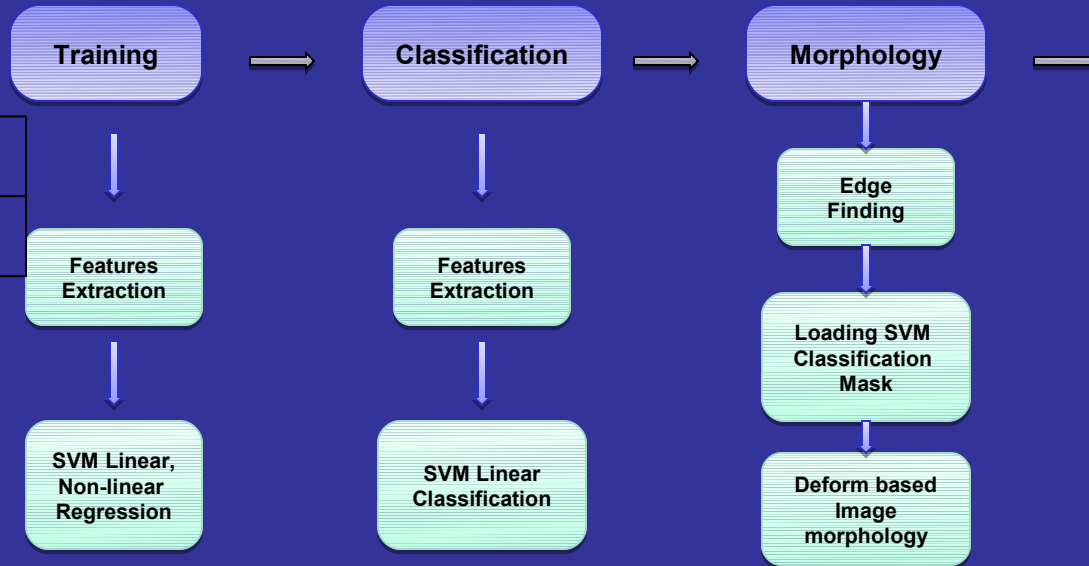
SVM based Automatic Prostate Segmentation on 3D

MRI images

Center slice as
the training base



- Haralick Texture
- Gabor
- Fuzzy-C Means

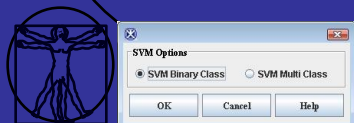
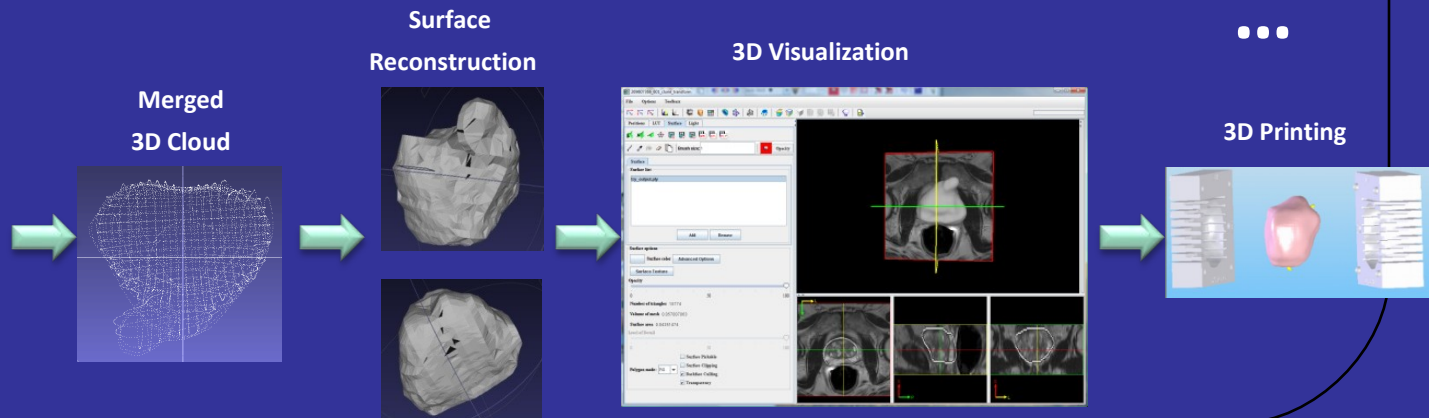


Automatic
Segmentation
on the rest slices



...

Automatic 3D MRI
Segmentation



OpenCL

Open Compute Language

Use the Graphics Processing Unit (GPU) as a
general massively parallel compute device.

Currently available for FFT

Soon to be available in other MIAPV Algorithms





M I P A V

Medical Image Processing, Analysis, & Visualization

