

# Transform

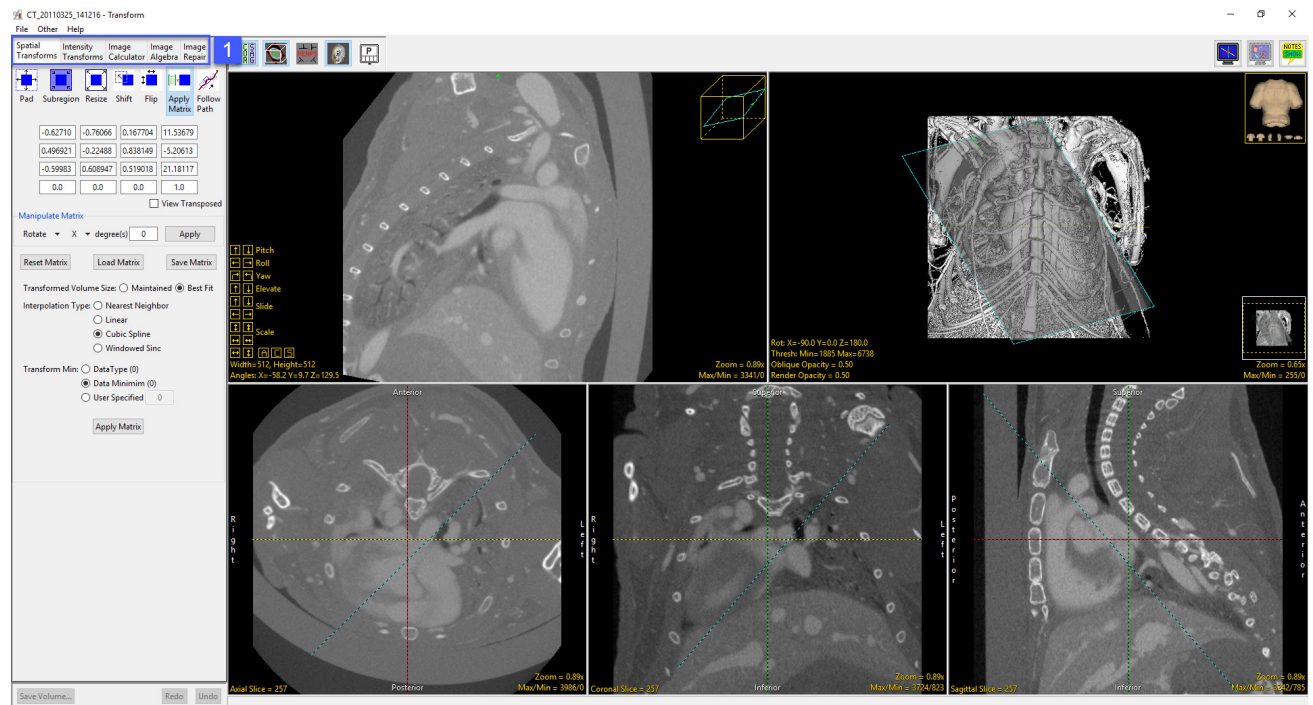
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# Introduction

There are several types of transformations that can be applied to data: **spatial transformations** such as cropping, resizing or flipping; **intensity transformations** such as thresholding, intensity scaling and inversion; and **custom transformations** using mathematical operators with image calculator/image algebra and image repair. All of this functionality is housed in the Transform module under five transformation tabs: [1]

1. Spatial Transforms
2. Intensity Transforms
3. Image Calculator
4. Image Algebra
5. Image Repair

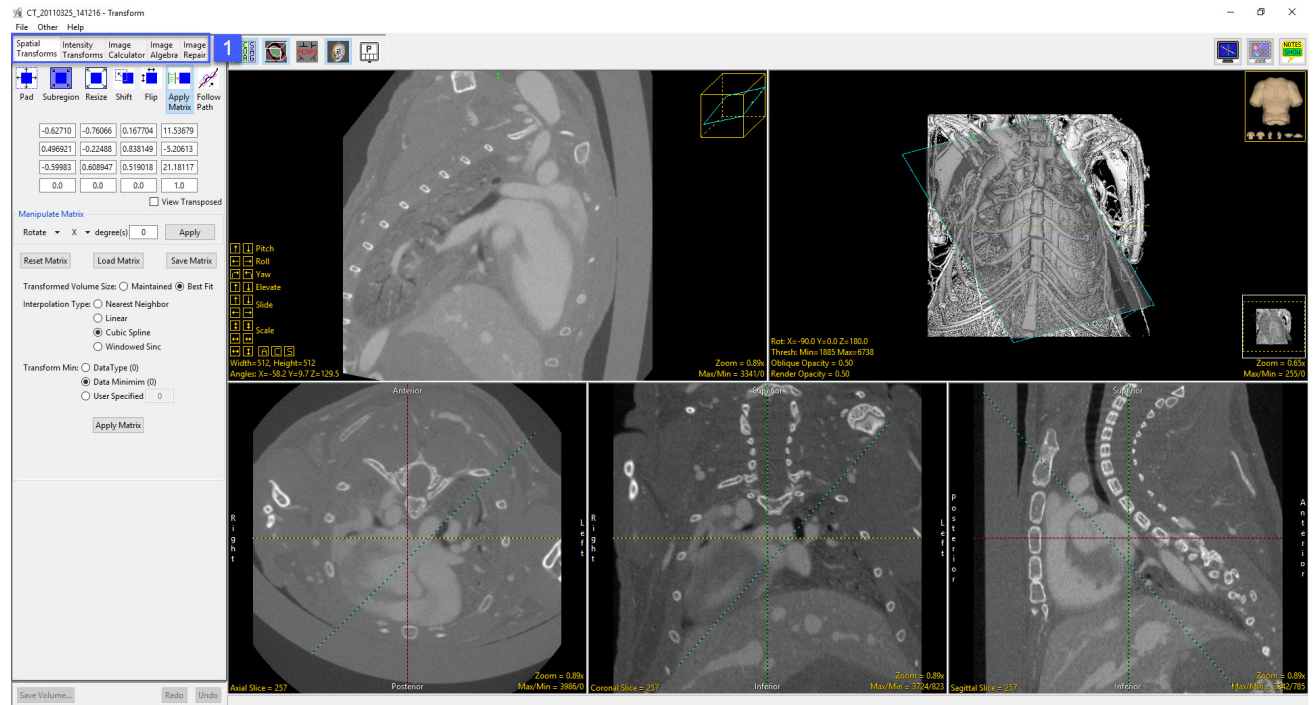


# Spatial Transforms

The Spatial Transforms tab [1] provides access to all the spatial transformation tools within Analyze including:

- Pad
- Subregion
- Resize
- Shift
- Flip
- Apply Matrix
- Follow Path

Many of the functions available in this section are also available in Input/Output under the Process tab, however, the implementation of these transformation tools within Transform take advantage of the new intuitive interface making data manipulation easier and quicker.





## Pad

The Pad tool can be used to add blank slices around the original data set. This may be necessary to create a data set with certain dimensions or with the same number of slices in each dimension. The options for this tool are as follows:

**Pad:** The padding options allow users to pad a data set. Padding places the Input volume in a larger output volume at the position specified by the padding values. The pad values specify the X, Y, and Z input volume starting and ending position in the output volume. The following padding options are available:

- **X Low:** The X Low field allows users to apply padding to the starting X position for the data set.
- **X High:** The X high field allows users to apply padding to the ending X position for the data set.
- **Y Low:** The Y Low field allows users to apply padding to the starting Y position for the data set.
- **Y High:** field allows users to apply padding to the ending Y position for the data set.
- **Z Low:** field allows users to apply padding to the starting Z position for the data set.
- **Z High:** field allows users to apply padding to the ending Z position for the data set.

**Equal Padding:** When the Equal Padding option is enabled a pad value entered in any of the pad fields will be applied to all fields, applying the same number of slices to each side of the volume.

**Pad Value:** The Pad Value option allows users to assign a specific grayscale value to be assigned to the padded regions in the output volume.

**Padded Volume:** The Padded Volume option allows users to specify the output dimensions of the volume.

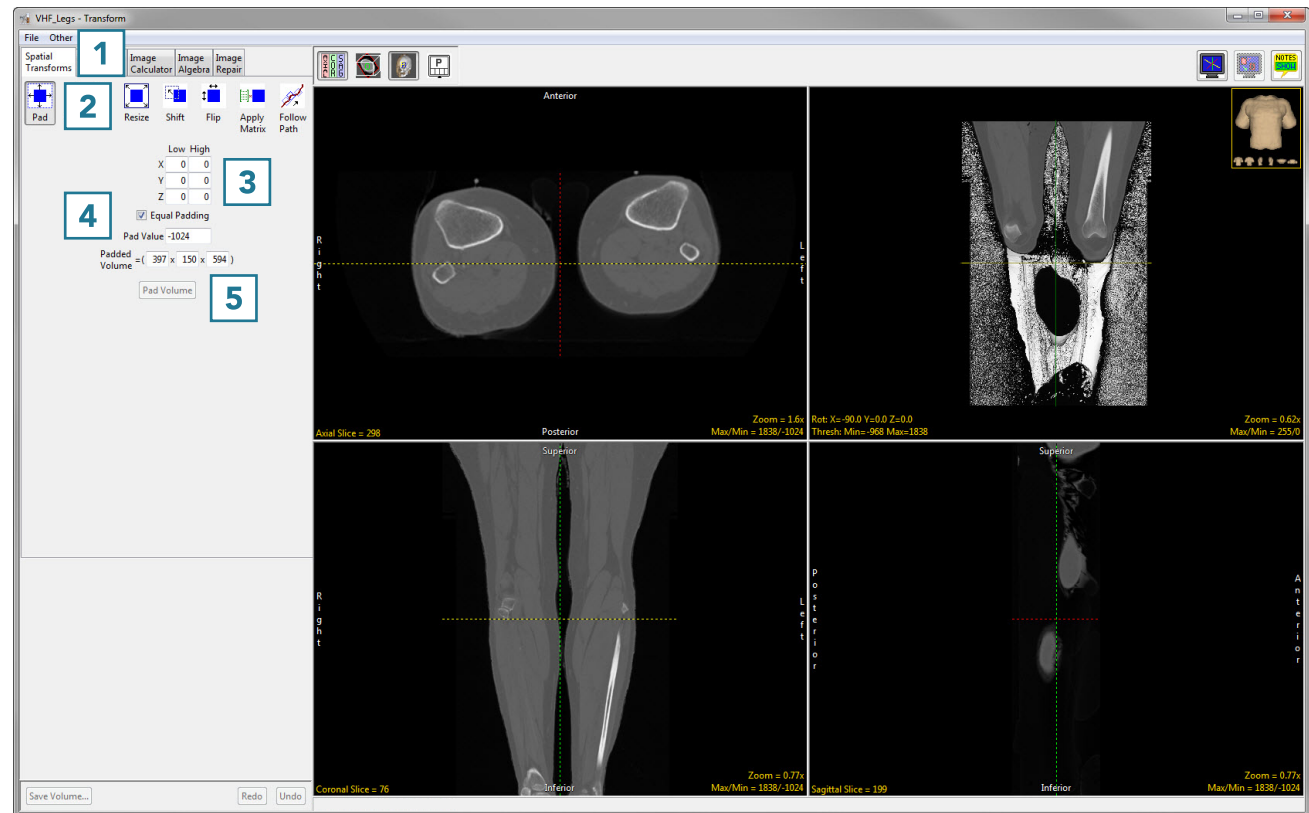
**Pad Volume:** Pads the input data based on the Pad parameters specified by the user.

## Using the Pad Tool

Here we use the Pad tool to add blank slices around the original data set.

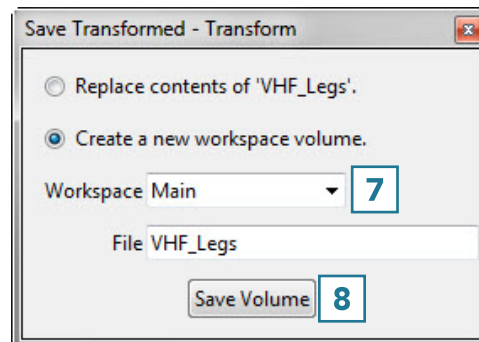
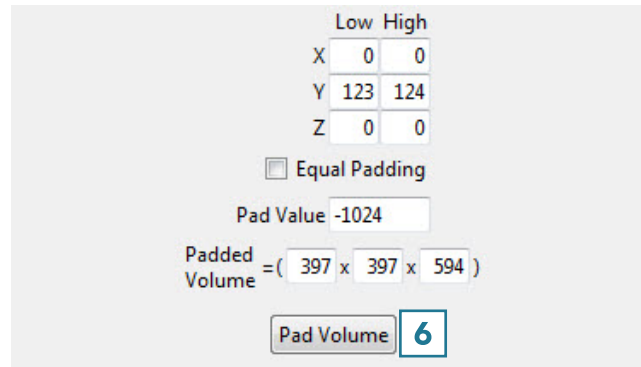
To follow along, download the data set VHF\_Legs from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

- Select the data set to pad and open Transform. Navigate to Spatial Transforms [1] and select the Pad tool [2].
- To add a given number of slices to the low or high end of the data set in any dimension, type the number of slices to be added in the appropriate boxes [3] and the padded volume dimensions will be updated.
- To change the intensity value of the added slices, change the Pad Value [4].
- To set the padded volume dimensions, change the numbers in the appropriate boxes [5] and the low and high number of slices in each dimension will update automatically.



## Using the Pad Tool (continued)

- Once the dimensions have been changed from the original dimensions, the Pad Volume button will update.
- Click Pad Volume to apply the changes [6].
- Click the Save Volume button to save the padded volume to the workspace. To retain the original volume, choose to create a new workspace volume, choose to create a new workspace volume [7] and click Save Volume [8].
- Close Transform.



## Subregion

The Subregion tool can be used to reduce the size of a data set without interpolating within the original data, or to crop to a specific region of interest. Available options are as follows:

**Subregion:** The subregion matrix provides users with an interface to specify the starting (Low) and ending (High) crop points in each orientation (X, Y, Z, and V). Users can also specify increment (Inc) and Number (Num) of slices to crop. The subregion matrix will update when subregions are defined using the interactive cropping tool from the slice display.

- **X:** The X row allows users to specify column attributes for cropping data. Column attributes are automatically updated to reflect changes when modified.
  - **Low:** Low allows users to specify the first column of pixels to be loaded.
  - **Inc:** The increment options allows users to specify increments between the first column of pixels from each image to be loaded.
  - **High:** High allows users to specify the last column of pixels to be loaded.
  - **Num:** Number allows users to enter the number of columns for each image to be loaded.
  - **Max:** The Max field reports the maximum number of columns to be loaded. Note that this field is not editable.
- **Y:** The Y row allows users to specify the row attributes for cropping data. Row attributes are automatically updated to reflect changes when modified.
  - **Low:** Low allows users to specify the first row of pixels to be loaded.
  - **Inc:** The increment options allows users to specify increments between the first row of pixels from each image to be loaded.
  - **High:** High allows users to specify the last row of pixels to be loaded.
  - **Num:** Number allows users to enter the number of rows for each image to be loaded.
  - **Max:** The Max field reports the maximum number of rows to be loaded. Note that this field is not editable.
- **Z:** The Z row allows users to specify the slice attributes for cropping data. Slice attributes are automatically updated to reflect changes when modified.
  - **Low:** Low allows users to specify the first slice to be loaded.
  - **Inc:** The increment options allows users to specify increments between slices.
  - **High:** High allows users to specify the last slice to be loaded.





## Subregion Options (continued)

### Subregion > Z (Continued):

- **Num:** Number allows users to enter the number of slices to be loaded.
- **Max:** The Max field reports the maximum number of slices to be loaded. Note that this field is not editable.
- **Z: Only enabled when a multivolume is selected.** The V row allows users to specify the volume attributes for cropping data. Volume attributes are automatically updated to reflect changes when modified.
  - **Low:** Low allows users to specify the first volume to be loaded.
  - **Inc:** The increment options allows users to specify increments between volumes.
  - **High:** High allows users to specify the last volume to be loaded.
  - **Num:** Number allows users to enter the number of volumes to be loaded.
  - **Max:** The Max field reports the maximum number of volumes to be loaded. Note that this field is not editable.

**Auto Crop:** The Auto Crop tool will automatically calculate the minimum enclosing area to crop image data in the selected orientation. Auto crop will remove empty space around data. This is a useful utility for removing black background slices or automatically cropping binary data. The following options are available:

- **Orientation:** Allows users to select the orientation to be used to calculate the minimum enclosing area. Choose from; Axial, Coronal, or Sagittal.
- **Slice(s):** Allows users to auto crop the current slice or all slices in the current orientation.
- **Crop:** Initiates the auto crop process.

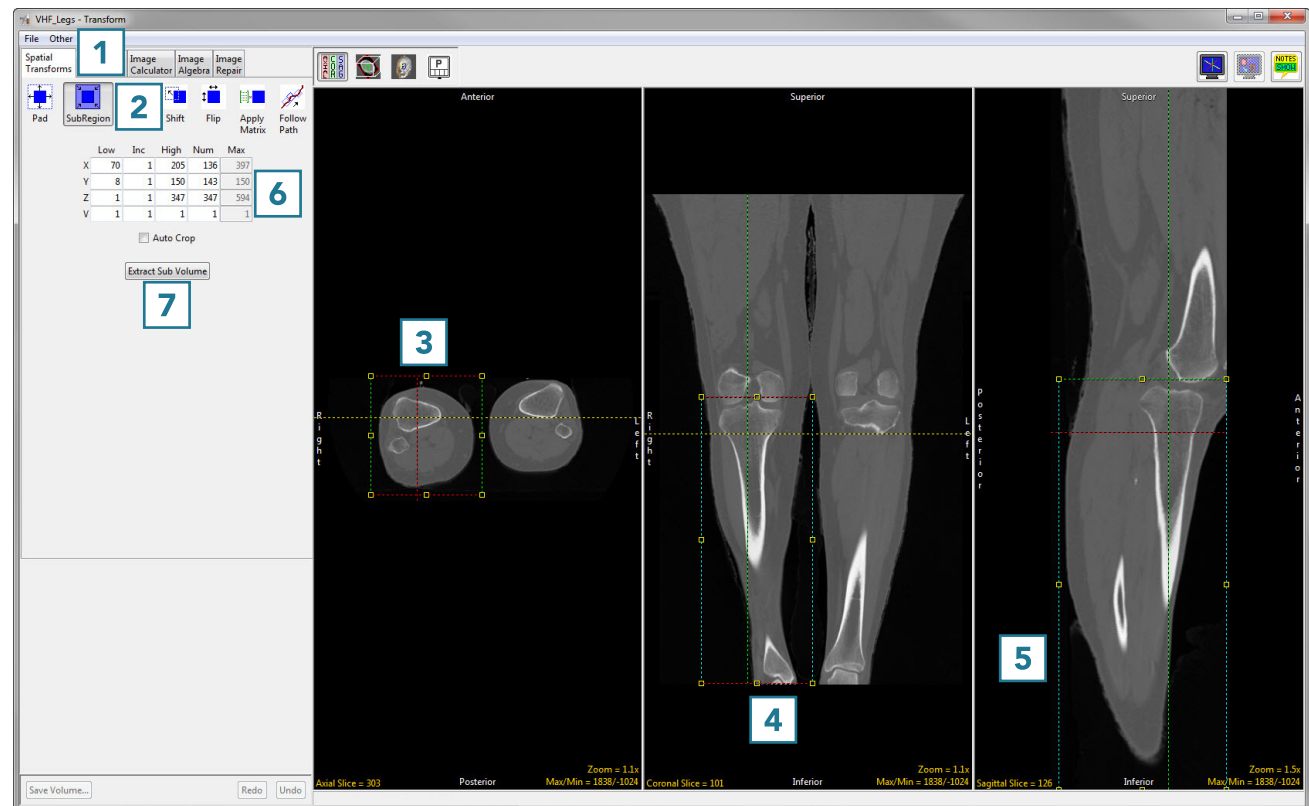
**Extract Sub Volume:** Extracts the sub volume utilizing the parameters specified in the subregion matrix.

## Using the Subregion Tool

Here we will use the Subregion tool can be used to crop a data set to a specific region of interest.

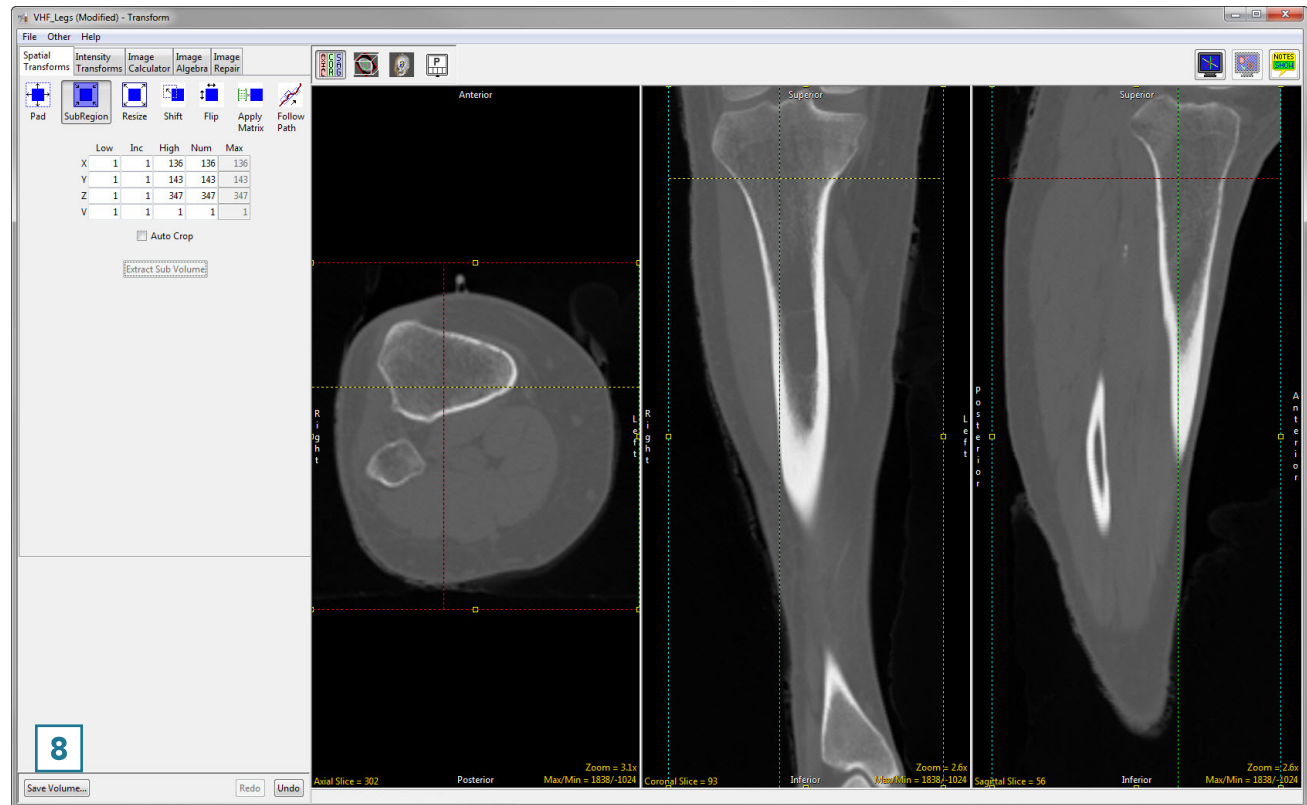
To follow along, download the data set VHF\_Legs from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

- Select the data set to crop and open Transform. Navigate to Spatial Transforms [1] and select the Subregion tool [2].
- Use the control points to set the cropped region in the axial [3], coronal [4] and sagittal [5] orientations. Scroll through the slices to ensure the region is correct throughout the data set.
- To set the cropped region to specific slice numbers, use the input boxes [6].
- Click Extract Sub Volume to perform the crop [7].

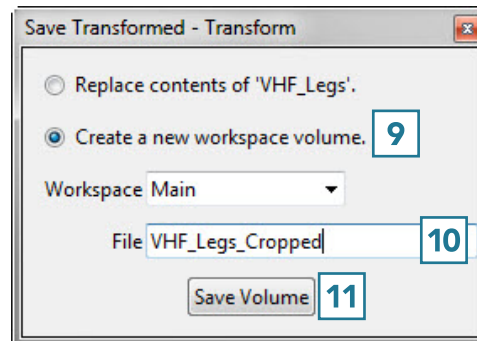


## Using the Subregion Tool (continued)

- Click Save Volume [8] to save the cropped data set.

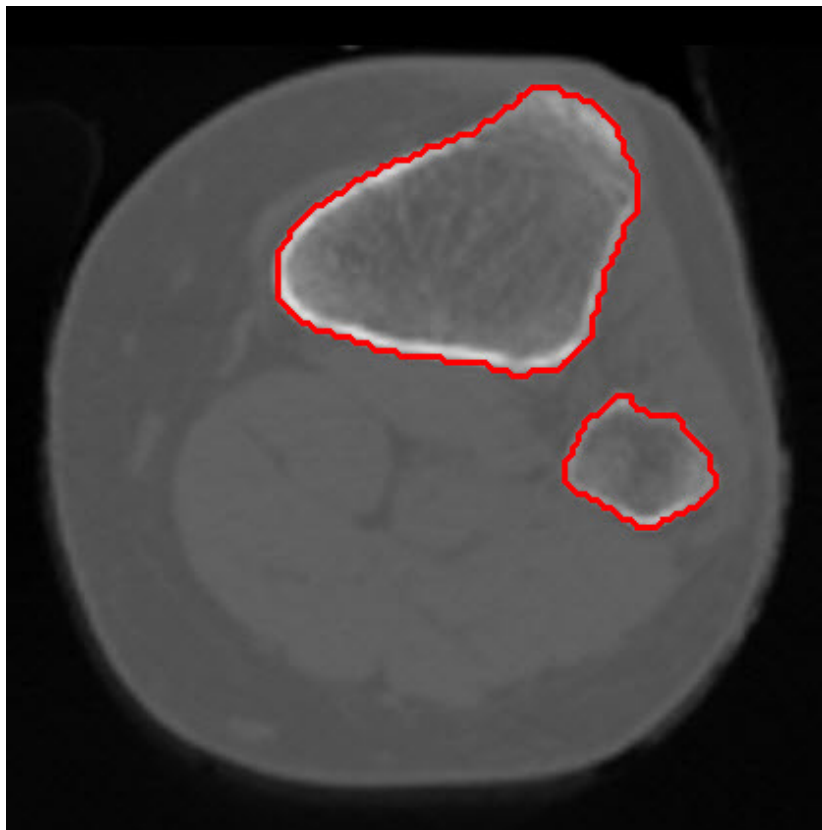


- To retain the original volume, choose to create a new workspace volume [9] and rename [10].
- Click Save Volume [11].
- Close Transform.

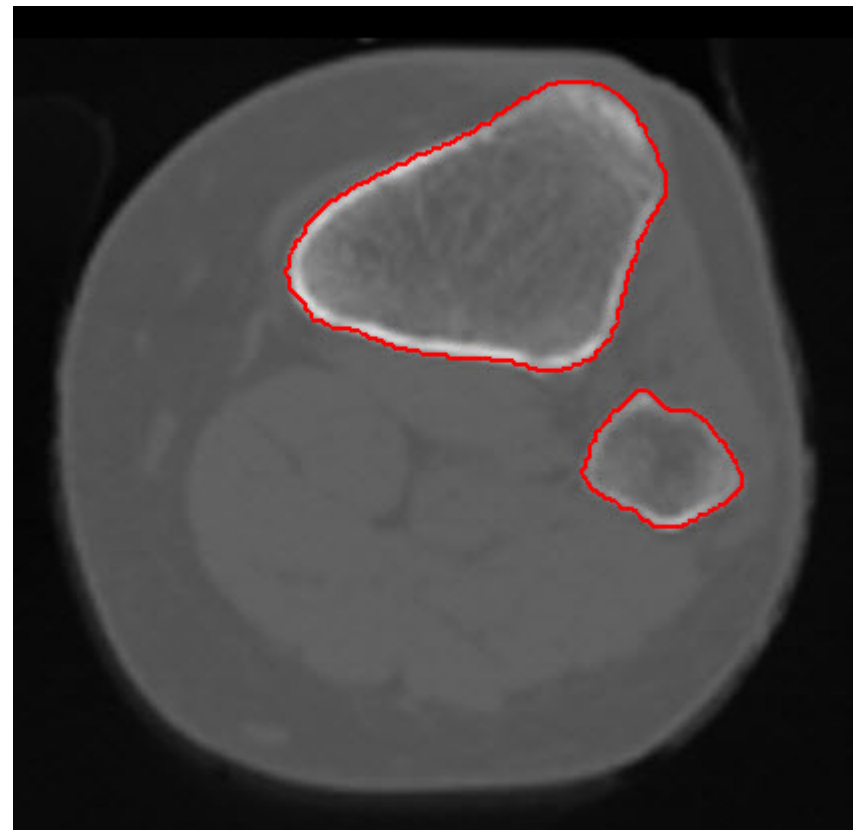


## Resize

The Resize tool can be used to resample image data. If data is acquired with anisotropic (non-cubic) voxels, the Resize tool can be used to resample the data to create an isotropic (cubic) data set. Occasionally data with a relatively large voxel size can be segmented more smoothly if resampled to a smaller voxel size. This will not change the resolution of the data but allows for a smoother definition of regions during segmentation.



Original Voxel Size



Resampled Voxel Size



## Resize Options

**Resize:** The resize tool allows users to perform tri-linear interpolation or voxel replication/sampling to resize a volume to a specific size. The interpolation parameters indicate the type of resize operation to perform. The following options are available:

**Input:** Displays the volume and voxel parameters of the input volume.

**Axis Dim:** Reports the voxel dimensions of the input volume:

- **X, Y, Z:** Displays the X, Y or Z dimension of the input volume.

**Memory:** Displays the size (memory usage) of the input volume.

**Voxel Size:** Reports the voxel size of the input volume. Note that the input X, Y, and Z values can be adjusted to accurately report the voxel size for the input volume.

- **X, Y, Z:** Displays the voxel width, height or distance between the slices of the input volume.

**Output:**

**Voxel Size:** Allows users to adjust the voxel size for the output volume. Note, when Force Cubic is selected, the individual X, Y, and Z fields are disabled leaving one value specifying the voxel size for X, Y, and Z in the output volume. When a voxel size is changed, the axis dimensions and memory usage are automatically calculated and updated to reflect the change.

- **X, Y, Z:** Allows users to specify the voxel width, height or distance between the slices for the output volume.

**Memory:** Reports the size (memory usage) for the output volume.

**Axis Dim:** The output axis dimensions display the voxel dimensions for the output volume. When a value is changed, the voxel size and memory usage are automatically calculated and updated to reflect the change.

- **X, Y, Z:** Specifies the X, Y or Z dimension of the output slice.

**Force Cubic:** When enabled, forces the output volumes voxel size to be cubic. This is useful when resizing anisotropic data to be isotropic.

**Interpolate:** Choose from Nearest Neighbor (ID), Linear (ID), Nearest Neighbor (OD), Linear (OD), Cubic Spline, Windowed Sinc or Shape Based to specify the interpolation method to use. See Table 6.1 for a full description of Interpolation Types.

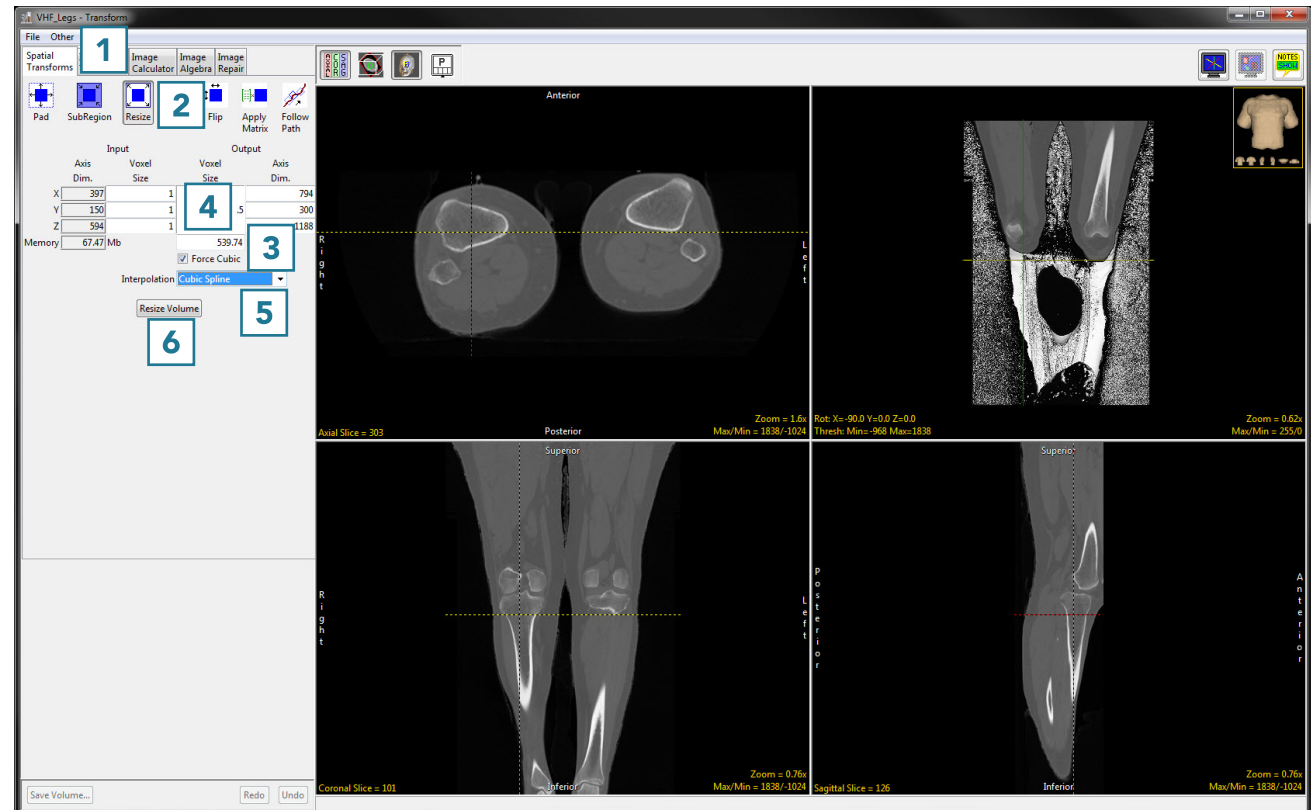
## Using the Resize Tool

To follow along, download the data set VHF\_Legs from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

- Select the data set to resize and open Transform. Navigate to Spatial Transforms [1] and select the Resize tool [2].
- Check the Force Cubic checkbox to interpolate between anisotropic voxels [3], set the new voxel size [4] and choose an interpolation type [5].

See the table on the following page for different interpolation types.

- Click Resize Volume [6] to resample the data set.





## Using the Resize Tool (continued)

Each interpolation type is either input driven (ID) or output driven (OD).

Input driven interpolation algorithms process each voxel in the input volume and map each input voxel into the output space. The actual interpolation takes place in the output space, given the projected contributions of each input voxel into that space. Input driven algorithms will always use every voxel in the input volume as part of the interpolation process.

Output driven algorithms step through each voxel in the output data set and find the corresponding set of voxels in the input data set that map into the output. The interpolation of voxels takes place in the input space, depending on the type of interpolation selected. Output driven algorithms are more common in image processing as they guarantee that every voxel in the output data set will be filled with an interpolated value.

## Interpolation Types

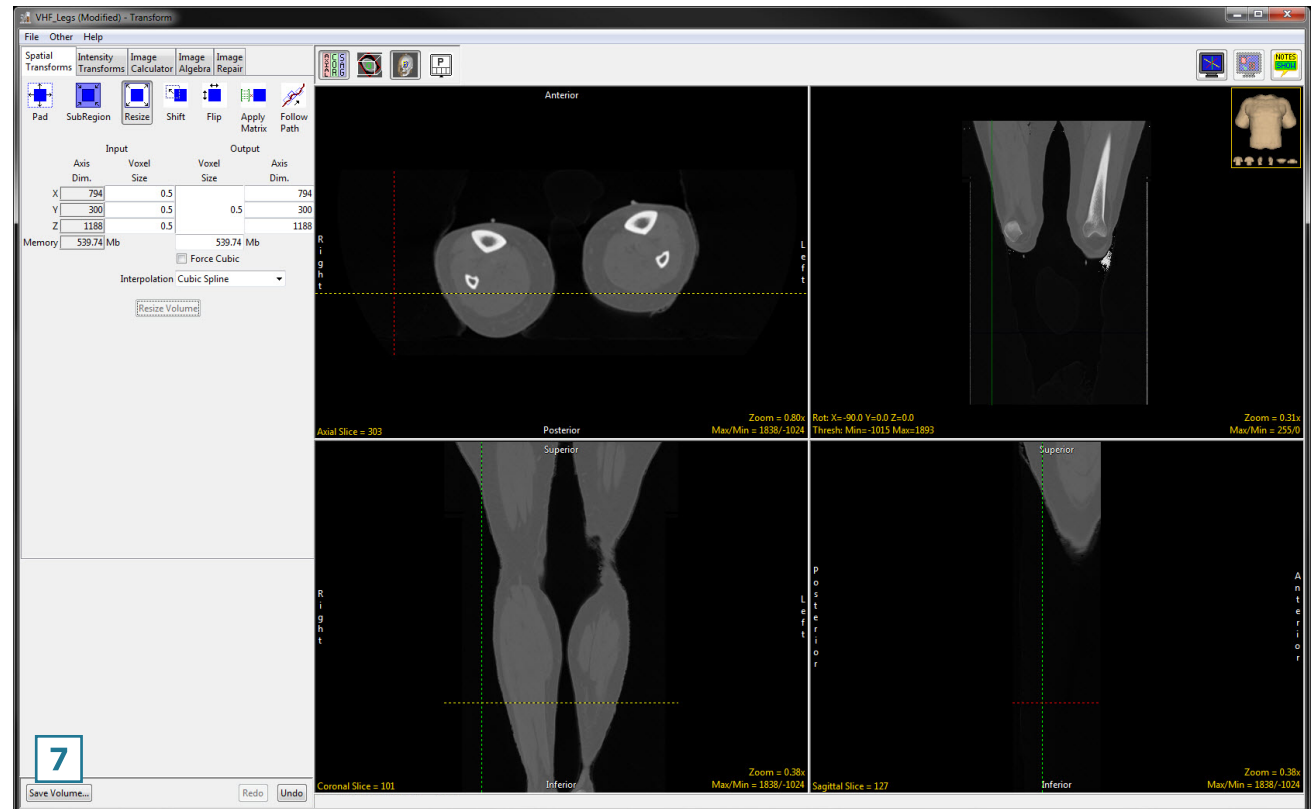
Interpolation Type	Description
Nearest Neighbor*	selects the value of the closest voxel to which the interpolation resampling maps
Linear*	applies a linear interpolation of grayscale intensity based on the distance of neighboring voxels from the interpolated voxel
Cubic Spline**	uses a cubic spline function to determine interpolated value
Windowed Sinc**	uses windowed sinc function $\sin(x)/x$ to determine interpolated value
Shape Based	only available for binary data; calculates Euclidean distance, then performs linear interpolation between distance images

\*The Nearest Neighbor and Linear interpolation types can be specified as ID or OD.

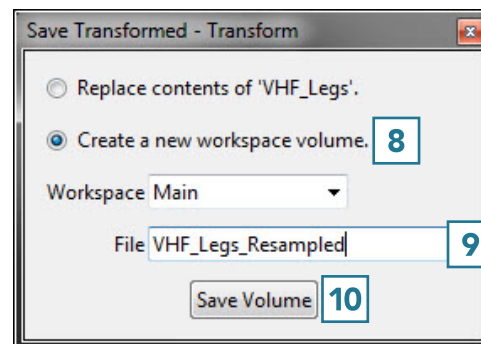
\*\*The Cubic Spline and Windowed Sinc interpolation types are both OD. Since they use higher-order functions, they account for more neighboring voxels and thus may provide a better estimate for the interpolated value. These algorithms are also more compute-intensive.

## Using the Resize Tool (continued)

- Click Save Volume [7] to save the resampled data set.



- To retain the original volume, choose to create a new workspace volume [8], rename [9] then click Save Volume [10].
- Close Transform.







## Shift

The Shift tool can be used to shift data horizontally or vertically. This may be necessary to correct wraparound artifacts. Available options are as follows:

**Shift:** Allows users to enter the number of voxels to shift data in the X, Y, or Z:

- **X:** Entering a number will apply a positive x shift (shift to the left). Entering a negative number will apply a negative x shift (shift to the right).
- **Y:** Entering a number will apply a positive y shift (shift forward). Entering a negative number will apply a negative y shift (shift backward).
- **Z:** Entering a number will apply a positive z shift (shift up). Entering a negative number will apply a negative y shift (shift down).
- **Wrap:** Allows users to specify if shifted voxels will wrap around when shifting.

**Shift Volume:** Applies the specified shift.

**Shear:** The Shear option allows users to apply horizontal and vertical shear correction in the Axial, Coronal, or Sagittal orientation. Note that Analyze automatically identifies and corrects for shear when loading data (see Shear Factor Correction in the Input/Output section of this manual).

- **Orient:** Choose from Axial, Coronal, or Sagittal.
- **Horizontal:** Allows users to specify the horizontal correction value for the selected orientation.
- **Vertical:** Allows users to specify the vertical correction value for the selected orientation.

**Shear Volume:** Applies the specified shear correction parameters.

## Using the Shift Tool

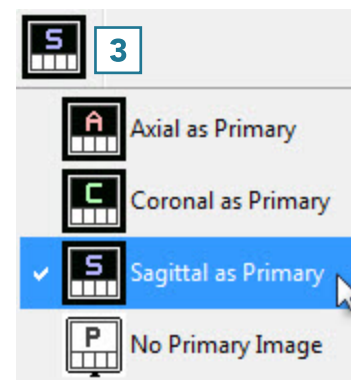
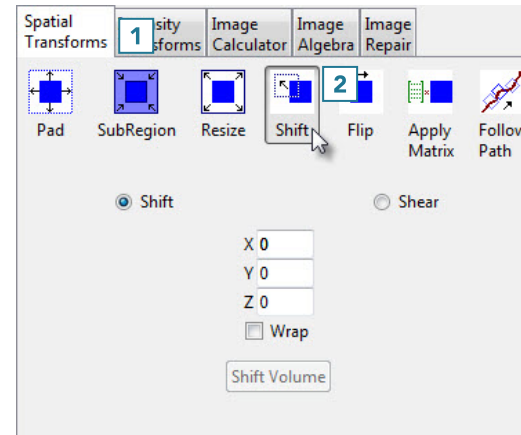
### Correcting Wraparound Using the Shift Tool

The Shift tool can be used to shift data horizontally or vertically.

This may be necessary to correct wraparound artifacts.

To follow along, download the data set MRI\_Head.avw from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

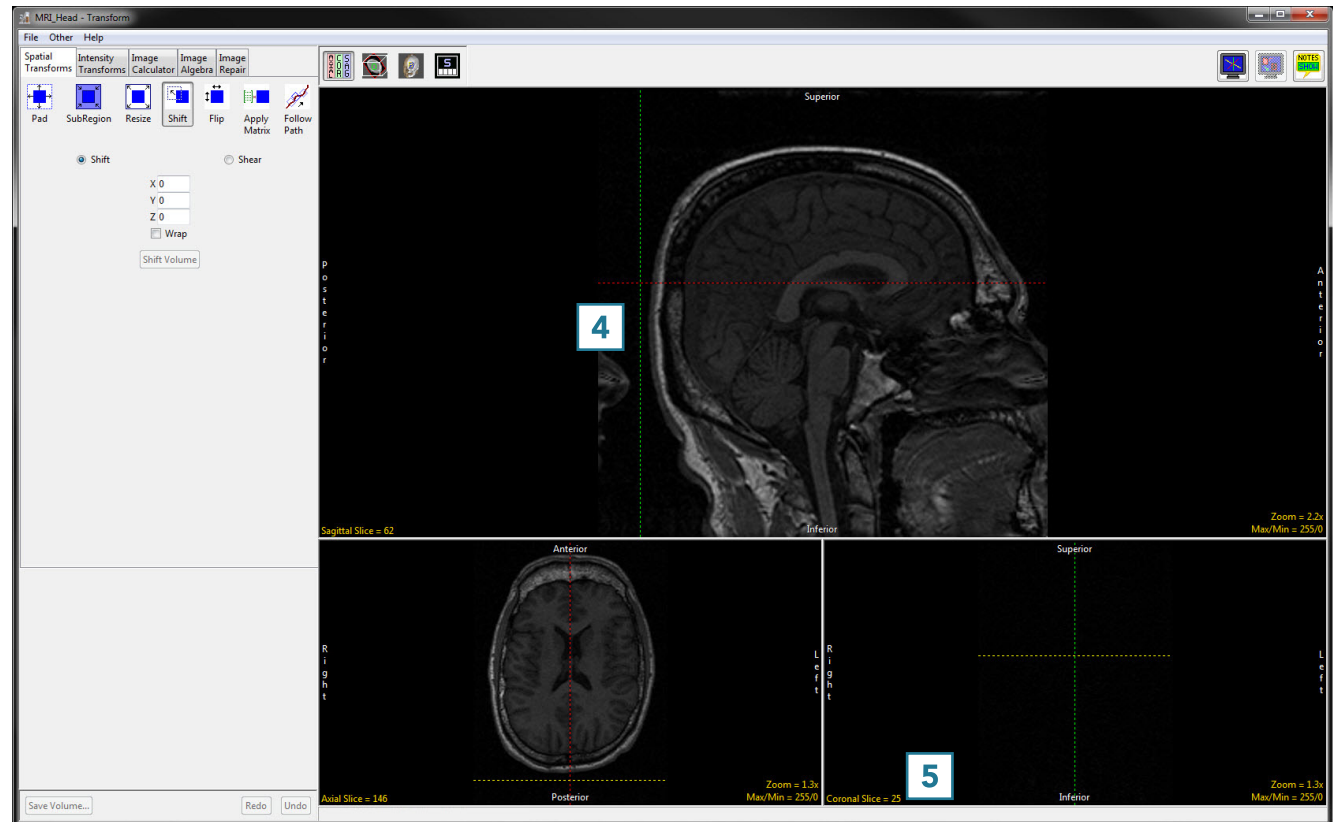
- Select the data set to shift and open Transform. Navigate to Spatial Transforms [1] and select the Shift tool [2].
- This data set has a wraparound artifact which is visible in the sagittal view.
- Set sagittal as the primary view by double-clicking on the sagittal image or using the primary view menu [3].



## Using the Shift Tool (continued)

- Use the linked cursor to determine the shift parameter value [4].
- In this data set, when the cursor is lined up with an appropriate break point in the sagittal view, the corresponding coronal slice number is 25 [5].

Refer to the table below to determine the correct sign and direction of the desired shift.

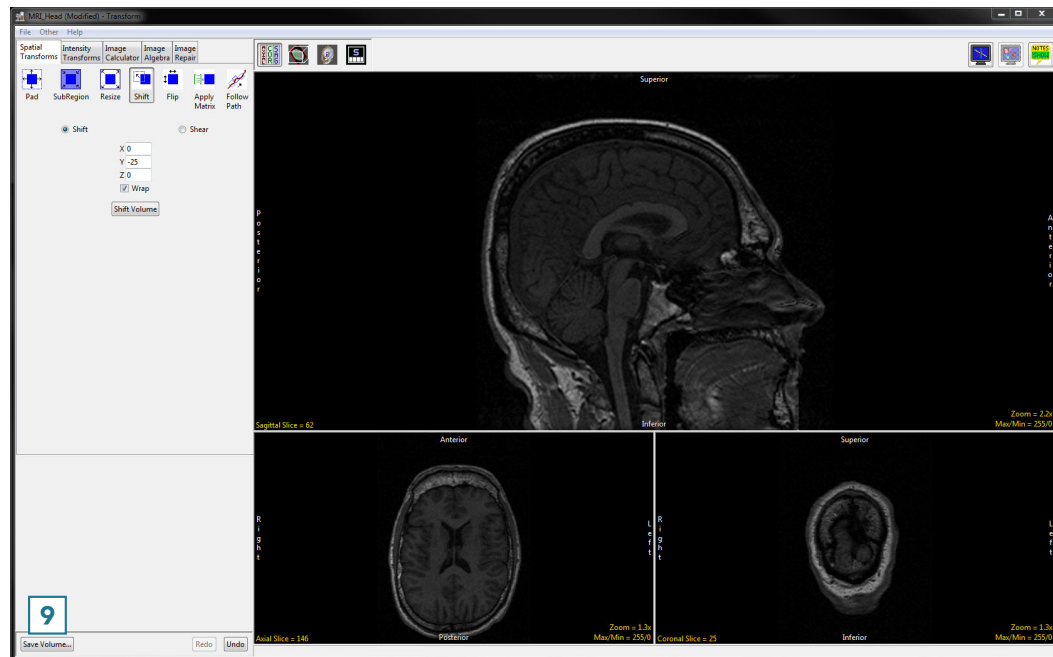
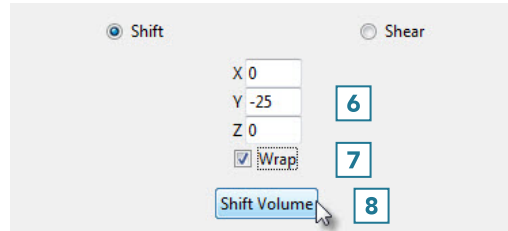


## Shift Parameters

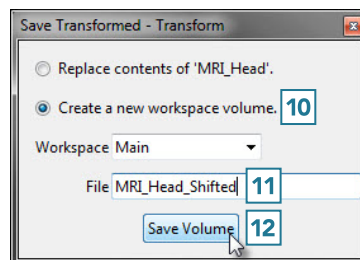
Parameter	Axial		Coronal		Sagittal	
	+	-	+	-	+	-
X	right	left	right	left		
Y	up	down			right	left
Z			up	down	up	down

## Using the Shift Tool (continued)

- Since we want to shift the sagittal image to the left, we will use a Y parameter of -25.
- Type this parameter value into the input box [6].
- Select the Wrap checkbox [7].
- Click Shift Volume to complete the shift [8].
- The data set will shift to the left by 25 slices and wrap those slices back around to connect with the rest of the head.
- Click Save Volume to save the shifted data set [9].



- In the Save Transformed window, choose to create a new workspace volume [10].
- Rename [11] and click Save Volume [12].
- Close Transform.



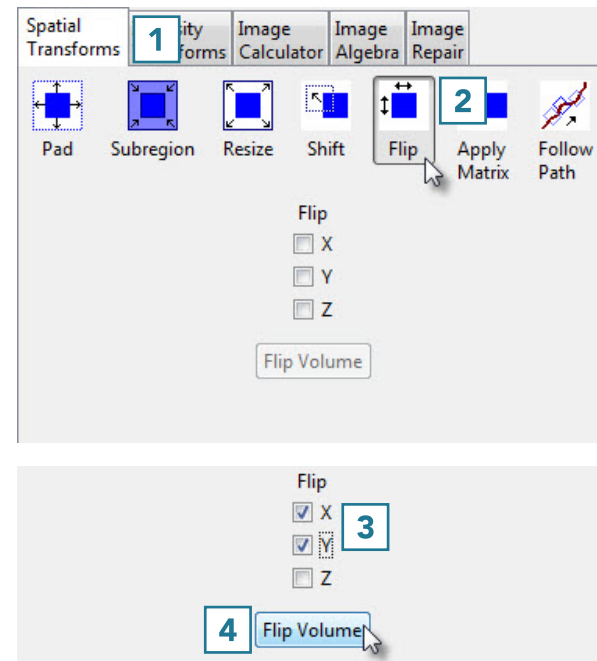
# Flip

In some cases, it may be necessary to flip data in order to orient it correctly. The Flip tool allows users to flip data along any single axis or combination of axes, according to the following parameters.

## Flip Parameters

Axis	Outcome
X	flips data horizontally about the vertical (Y) axis
Y	flips data vertically about the horizontal (X) axis
Z	reverses the order of the slices

Flipping the data in only the X or Y direction will create a mirror image. If this is not the desired result, the data can be flipped in both the X and Y directions at once to prevent a mirror image from being created.



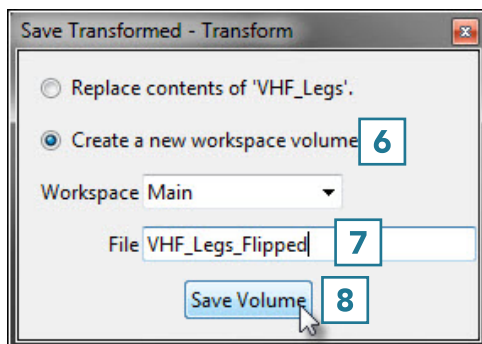
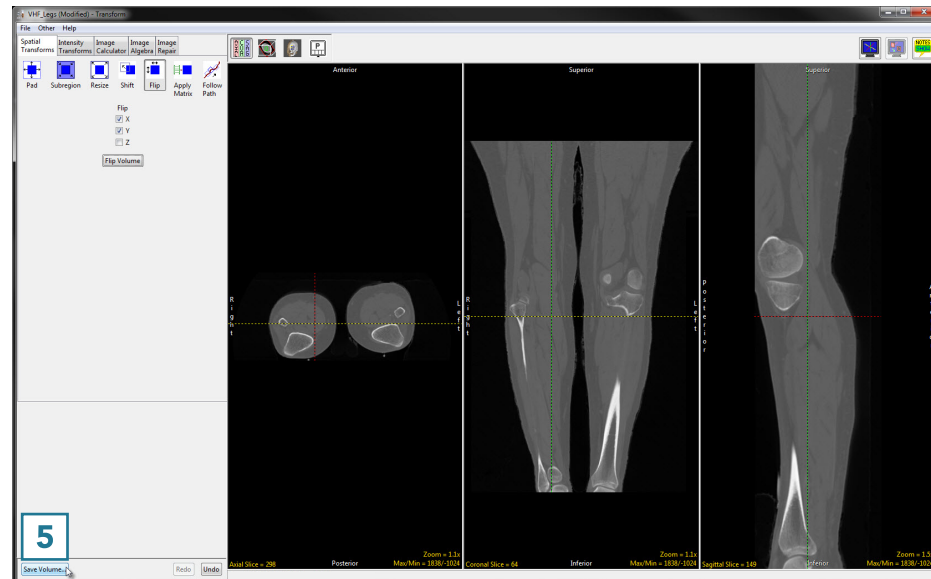
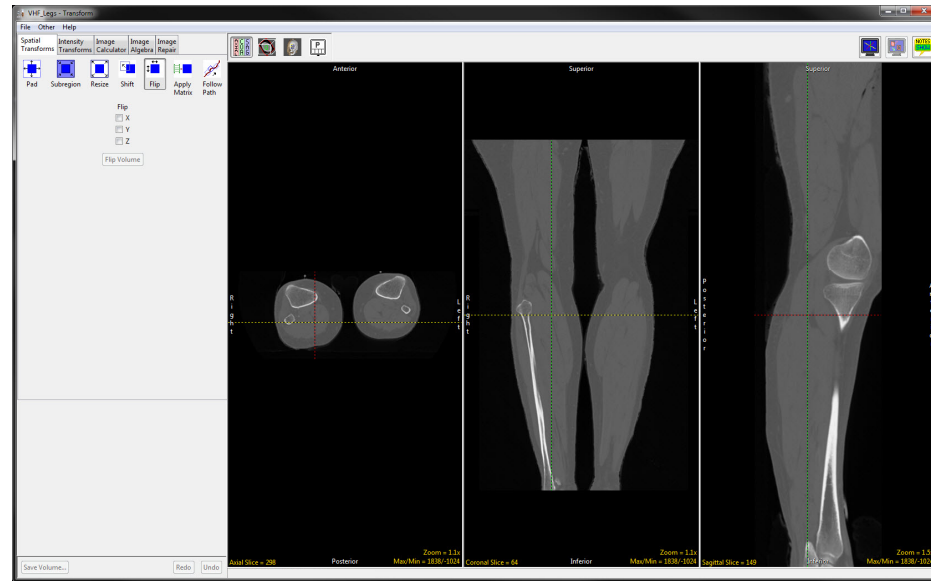
## Flipping Data

To follow along, download the data set VHF\_Legs from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

- Select the data set to flip and open Transform. Navigate to Spatial Transforms [1] and select the Flip tool [2].
- Select the checkboxes for the directions you wish to flip the data [3]. We will flip this data in the X and Y directions to avoid creating a mirror image.
- Click Flip Volume [4] to apply the flip.

## Flip (continued)

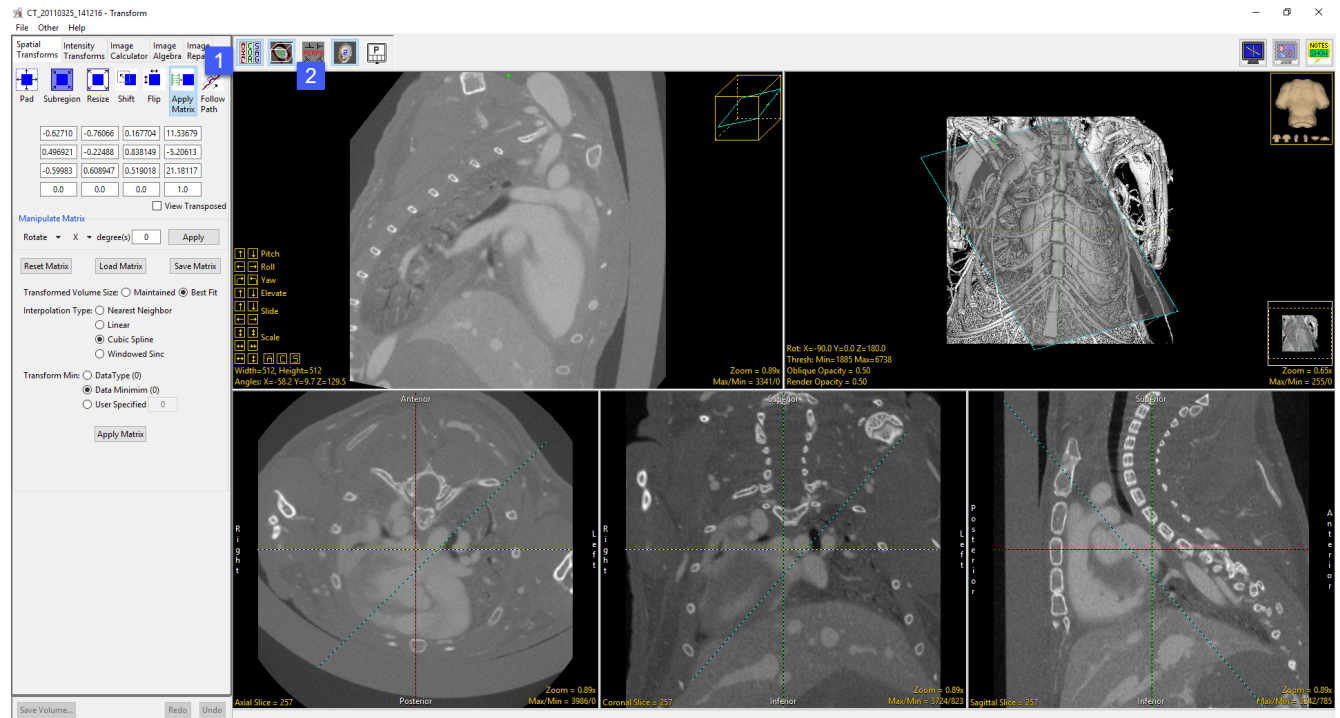
- Here, the data set before and after the X-Y flip is shown. Once the data is flipped, click Save Volume to save the flipped data set [5].
- In the Save Transformed window, choose to create a new workspace volume [6].
- Rename [7] and click Save Volume [8].
- Close Transform.



# Apply Matrix

The Apply Matrix tool [1] when used in conjunction with the Oblique tool [2], can spatially transform a data set in many different ways, including rotation, translation and scaling (stretching or compressing) along any axis, and inversion. In addition, any 4x4 matrix can be loaded into the tool to apply the same transformation to many data sets.

Another prominent feature of this tool is the ability to output oblique data sets, such as AC-PC aligned brain data. The AC-PC line (anterior commissure - posterior commissure line) also known as the bicommissural line, has been adopted as a standard by the neuroimaging community, and in most instances is the reference plane for axial imaging in everyday scanning.





## Apply Matrix Options

**Matrix:** The matrix tool enables specification, application, loading, and saving of transformation matrices. The matrix displays a 4 x 4 the identity matrix for the data and will update to a transformation matrix when manipulations are made to the matrix. Adjustments can be made directly in any of the matrix fields; however, this is not recommended, instead use the manipulate matrix tools or the Obliques Window to adjust.

- **View Transposed:** When selected, inverts the transformation matrix.

**Manipulate Matrix:** Allows users to manipulate the transformation matrix. The following options are available:

- **Rotate:** Rotates the transformation matrix. Users can select to rotate the X, Y, and Z degree of rotation. The rotation is applied to the X axis first, then the Y axis, and finally the z axis.
  - **X, Y, Z:** Specifies that the transformation matrix will be rotated about the X, Y or Z axes.
  - **Degrees:** Specifies the degree of rotation.

**Translate:** Allows users to apply translations. Translations are applied to the X, Y, and Z.

- **X, Y, Z:** Specifies that the transformation matrix will be translated in X, Y or Z.
- **Voxels:** Specifies the number of voxels to translate.

**Scale:** Modifies the transformation matrix by a specified scale factor.

- **X, Y, Z:** Specifies that the transformation matrix will be scaled in X, Y or Z.
- **Factor:** Specifies the scale factor.

**Identity:** Sets the transformation matrix to the identity matrix.

**Invert:** Inverts the transformation matrix.

**Apply:** When selected, applies the specified manipulations options to the transformation matrix.





## Apply Matrix Options (continue)

**Reset Matrix:** Resets the Matrix.

**Load Matrix:** Allows users to load previously saved matrix files.

**Save Matrix:** Allows users to save the current matrix file.

**Isotropic Scaling:** When anisotropic (non-cubic) data is loaded into Transform it is automatically scaled to isotropic (cubic) voxels. The Isotropic Scaling option will be enabled and set to Yes.

- **Yes:** This is the default option. Anisotropic data is automatically resampled to be isotropic. This enables the application of any transformation, as detailed above, and allows for the generation of a transformed volume in the isotropic space. The saved volume will have spatially correct, transformed voxels.
- **No:** Disables anisotropic resampling, please note that this is not recommended. Users should only select this option if they wish to save out anisotropic data, however, the transformed spatial voxel size will not be known and users will be prompted to remove the voxel spatial information from the header or copy the original isotropic voxel size from the input volume when saving the data.

**Transformed Volume Size:** Allows users to choose between Best Fit or Maintained to specify if the saved volume should be resize to best fit the data (recommended) or if it should maintain the original volume dimensions.

**Interpolation Type:** Allows users to specify the interpolation type to be used when transforming the data. Choose from Nearest Neighbor, Linear, Cubic Spline, or Windowed Sinc.

**Transform Min:** Allows users to select the grayscale value of additional/new background voxels. Choose between; Data Type, Data Minimum, or User Specified.

**Apply Matrix:** When selected, applies the specified transformation matrix to the image data.

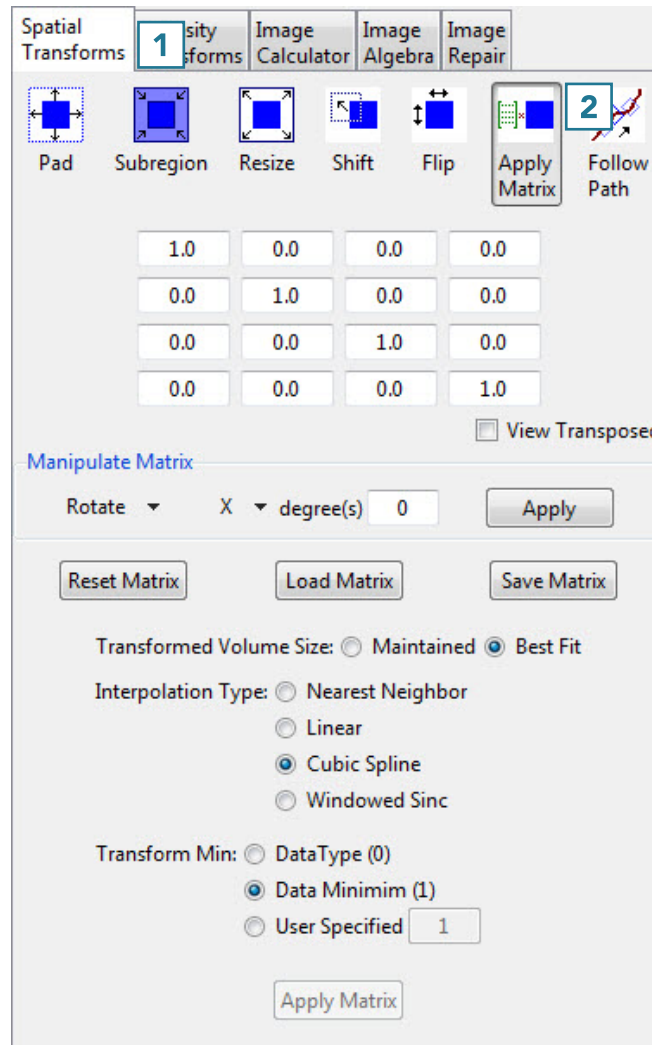
## Using the Apply Matrix Tool

### AC-PC Alignment of Brain Data

In this exercise we will use the tools available in the Transform module to align an MRI scan of the brain along the AC-PC axis.

To follow along, download the data set MRI\_Head.avw from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

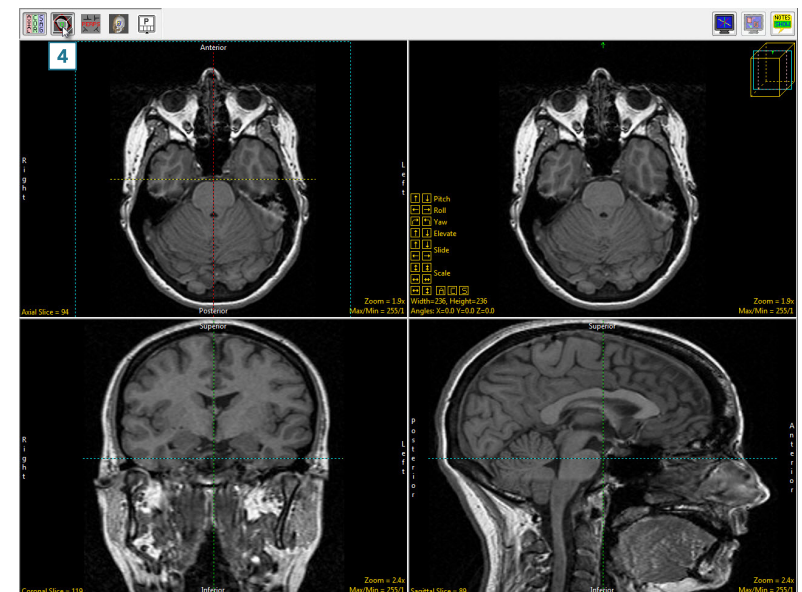
- Select the data set to align along the and open Transform.
- Navigate to Spatial Transforms [1]
- Select the Apply Matrix tool [2].



## Using the Apply Matrix Tool (continued)

The optimal display settings for AC-PC alignment or any other manipulation of an oblique plane are as follows:

- Switch off the rendering [3] (unless an object map is loaded, which might help visualize the oblique). Now the three orthogonal views are shown.
- Switch on the oblique [4]. Now, the oblique and the three orthogonal views are shown.

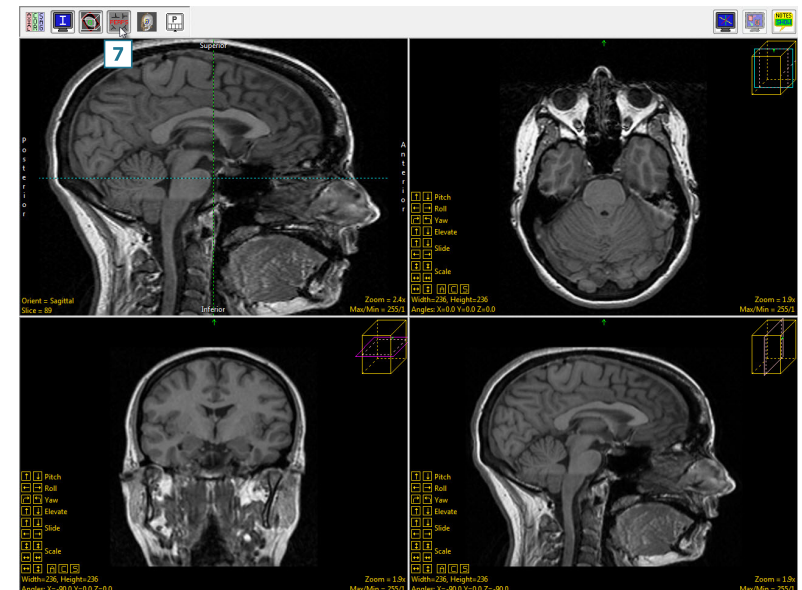


## Using the Apply Matrix Tool (continued)

- Toggle the orthogonal orientations to a single image [5].
- Set this image to the sagittal view by clicking twice on the Orient parameter [6].
- Now the sagittal orientation and the oblique image are shown.

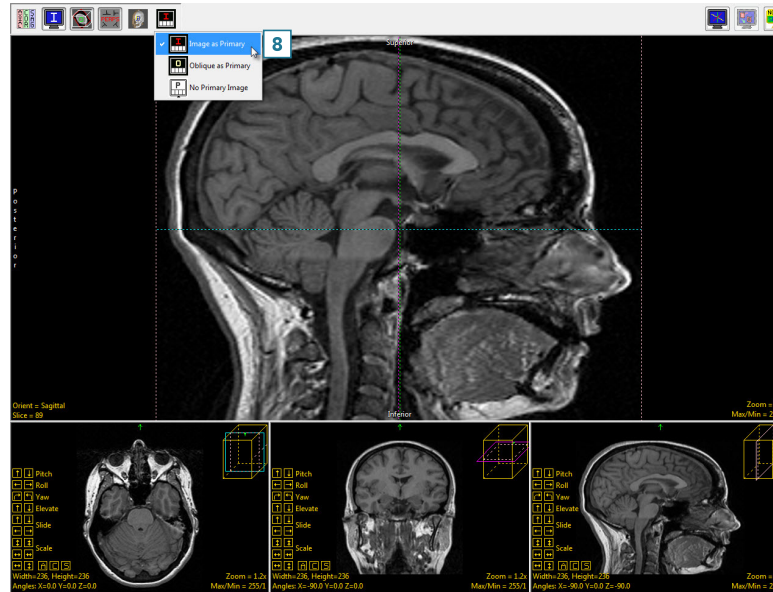


- Switch on the perpendicular images [7].

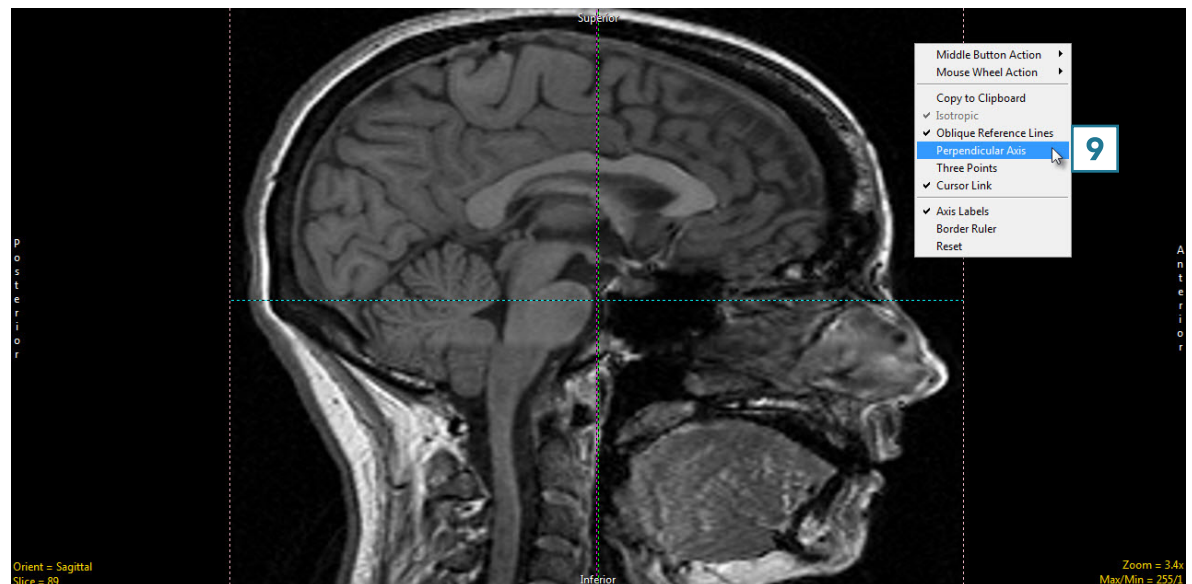


## Using the Apply Matrix Tool (continued)

- The AC-PC line will be defined on the sagittal view, so double-click the sagittal image or select Image as Primary in the drop-down menu [8].



- Right-click on the sagittal image and select Perpendicular Axis [9] to turn on the perpendicular axis tool.



## Using the Apply Matrix Tool (continued)

- Navigate to the mid-sagittal slice, which for this data set is slice 90 [10].
- Drag the left endpoint of the perpendicular axis to the posterior commissure [11].
- Drag the right endpoint of the perpendicular axis to the anterior commissure [12].

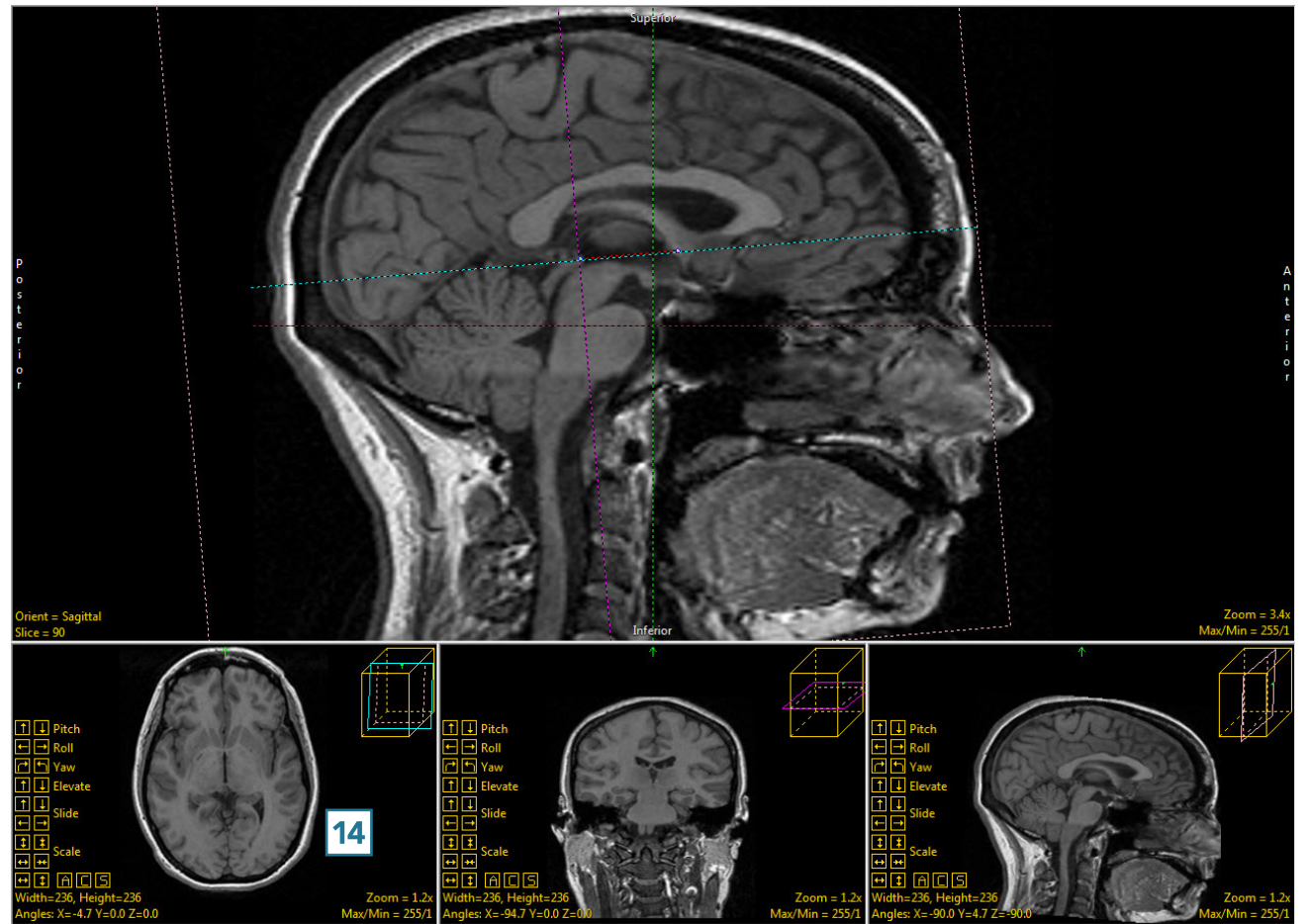


- To set the oblique plane to be parallel, rather than perpendicular, to the AC-PC plane, right-click on one of the perpendicular axis endpoints and set the Matrix to Create to Parallel [13].



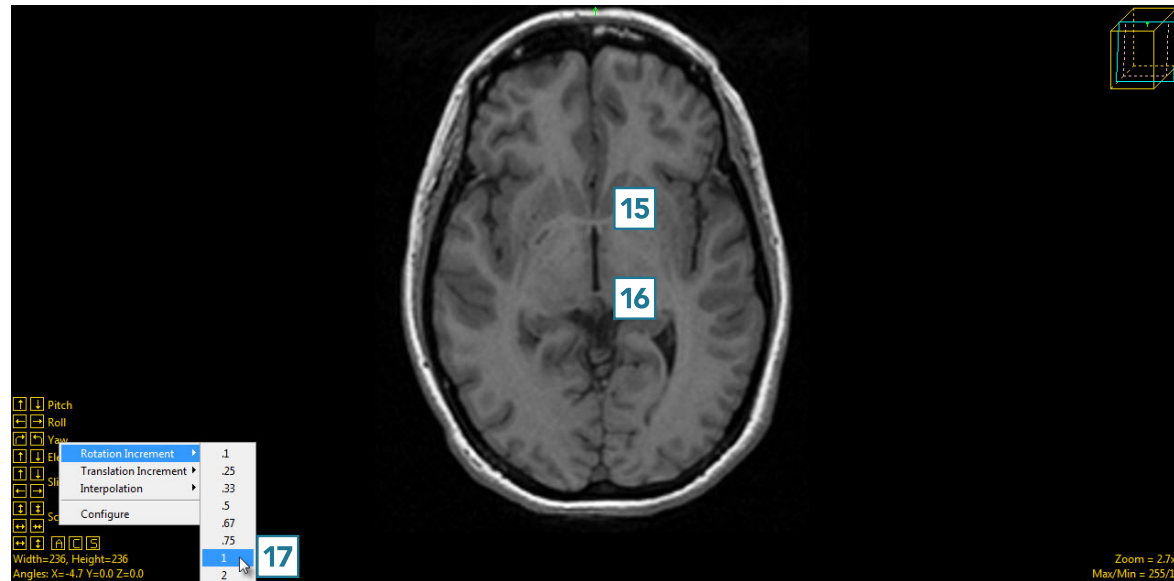
## Using the Apply Matrix Tool (continued)

- Now the main oblique image (the leftmost of the three) is an AC-PC aligned axial image [14].
- Double-click this image to make it the primary image.

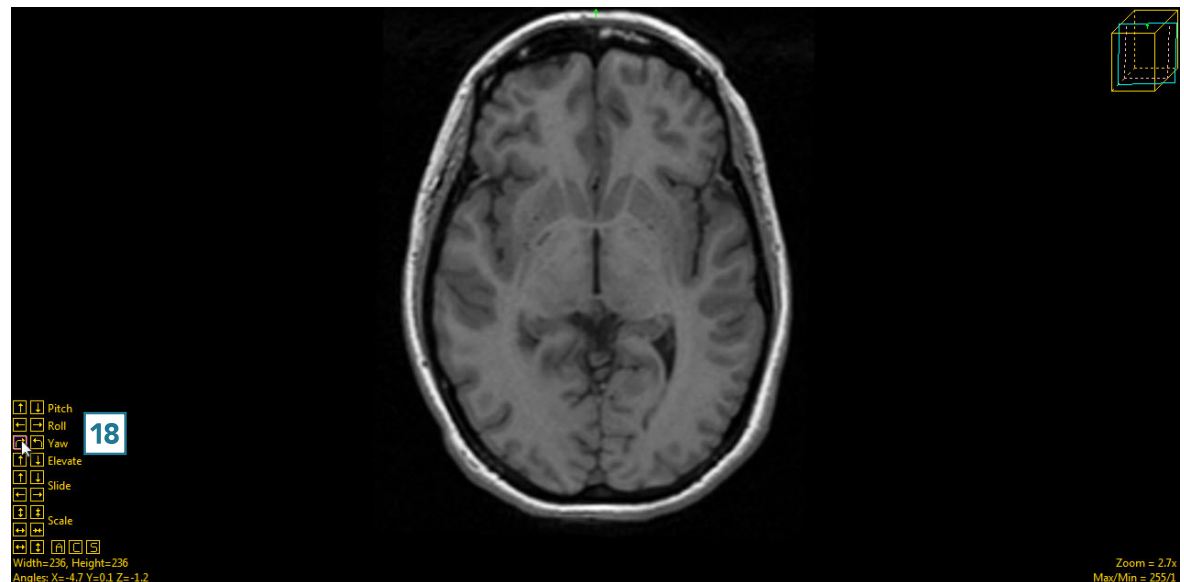


## Using the Apply Matrix Tool (continued)

- The AC [15] and PC [16] can both be seen on the same oblique slice, indicating good AC-PC alignment.
- To adjust vertical alignment of the data set, right-click Yaw and set the Rotation Increment to 1 [17].



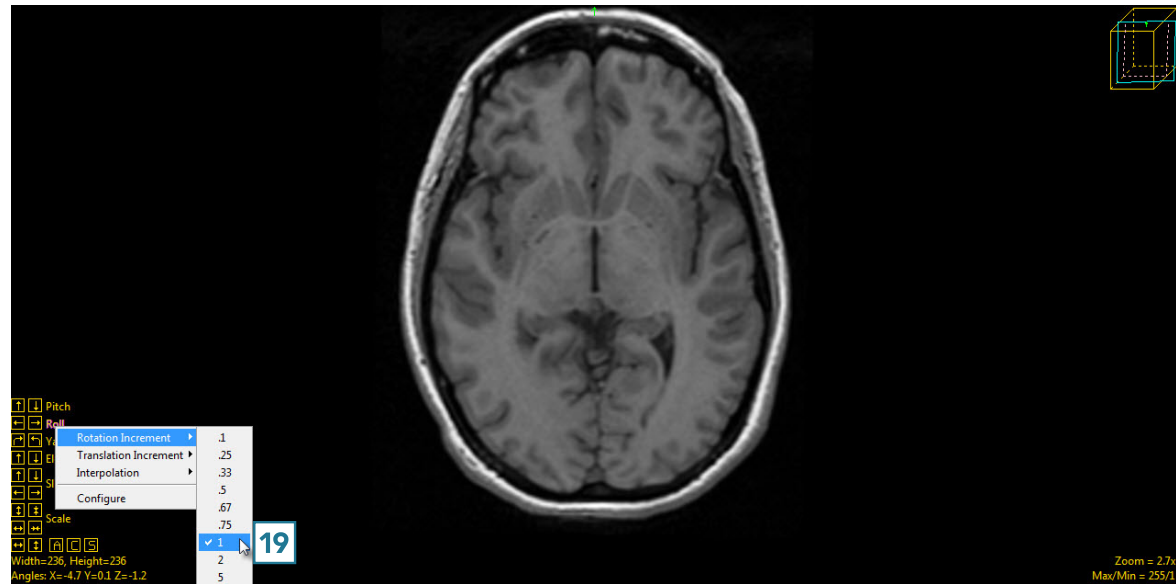
- Use the left and right Yaw buttons to align the data set vertically [18]. The increment can be made even smaller to make smaller adjustments as needed.



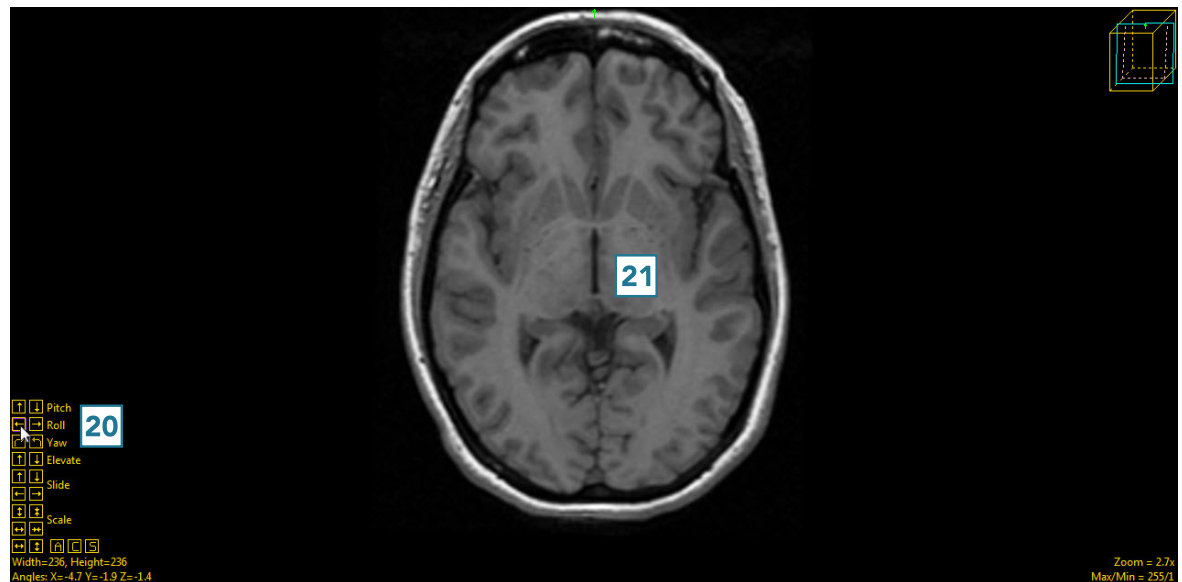


## Using the Apply Matrix Tool (continued)

- The last adjustment to be made to the oblique plane will be done using the Roll function. Right-click on Roll and change the Rotation Increment to 1 [19].



- Click on the left and right roll buttons [20] to adjust the data set until the anatomical structures appear symmetrical [21].



## Using the Apply Matrix Tool (continued)

- Click Apply Matrix [22] to apply the transformation.

Pad Subregion Resize Shift Flip Apply Matrix Follow Path

0.999238	0.020560	-0.03315	0.106856
-0.01745	0.995657	0.091437	19.57691
0.034894	-0.09078	0.995258	-21.9265
0.0	0.0	0.0	1.0

View Transposed

Manipulate Matrix

Rotate X degree(s) 0 Apply

Reset Matrix Load Matrix Save Matrix

Transformed Volume Size:  Maintained  Best Fit

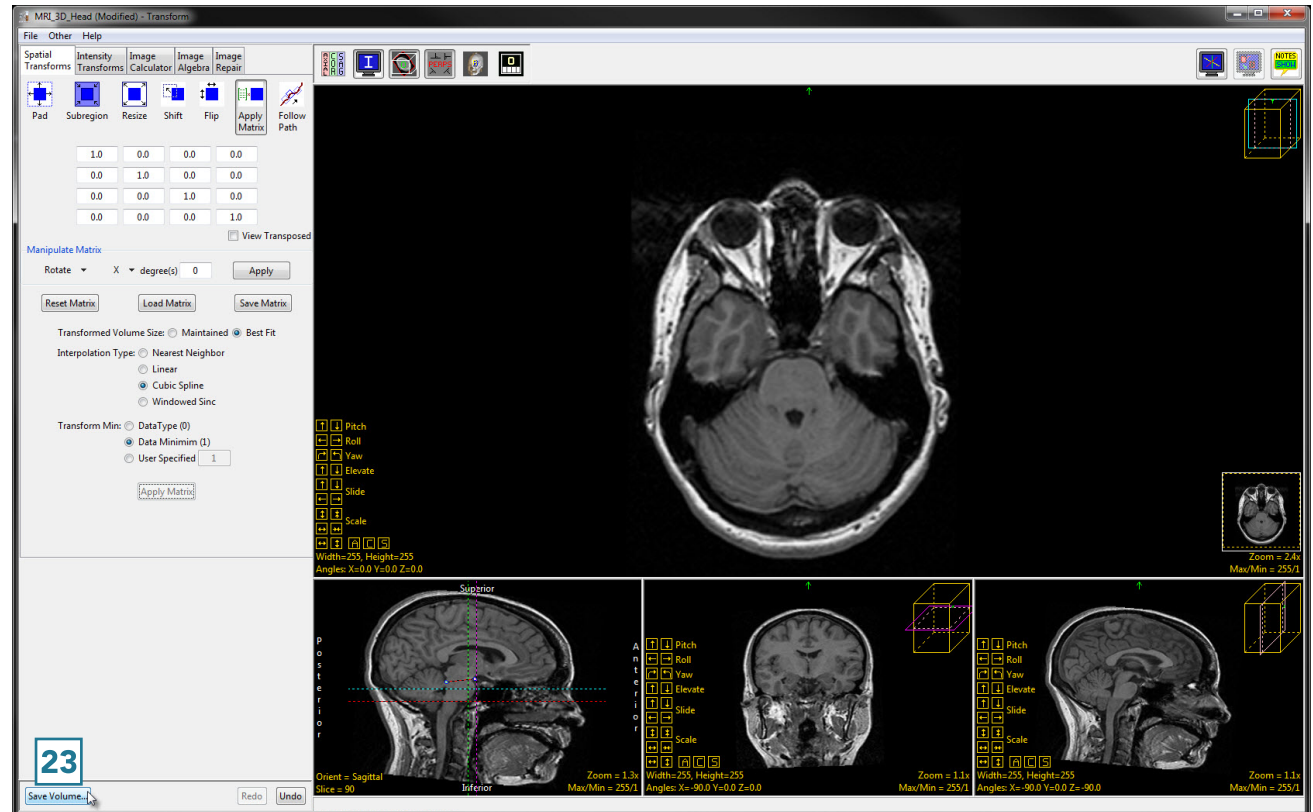
Interpolation Type:  Nearest Neighbor  
 Linear  
 Cubic Spline  
 Windowed Sinc

Transform Min:  DataType (0)  
 Data Minimum (1)  
 User Specified 1

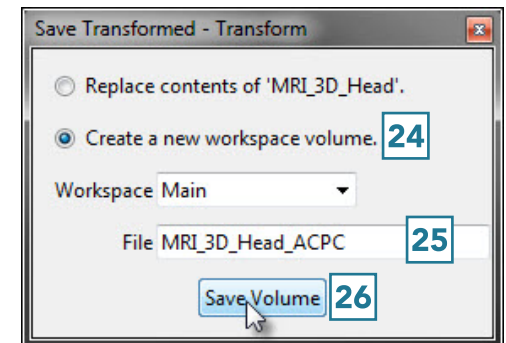
Apply Matrix 22

## Using the Apply Matrix Tool (continued)

- Click Save Volume [23] to save the transformed data set.



- In the Save Transformed window, choose to create a new workspace volume [24].
- Rename [25] and click Save Volume [26].
- Close Transform.



## Using the Apply Matrix Tool (continued)

### Data Reorientation

The Apply Matrix option can be used to reorient data. An example of this can be found when using the Analyze Bone Microarchitecture Analysis (BMA) Add-On, which requires that the input bone specimens are orientated into a specific orientation [1] as a prerequisite for bone tissue classification and measurement. The Oblique reorientation tools and Apply Matrix option in Transform provide the tools necessary to successfully re-orientate the image data for analysis.



In this exercise we will use the tools available in the Transform module to correctly orient a micro-CT bone data set for processing in the BMA add-on module.

To follow along, download the data set BMA\_PE\_micro\_CT.avw from [analyzedirect.com/data](https://analyzedirect.com/data)

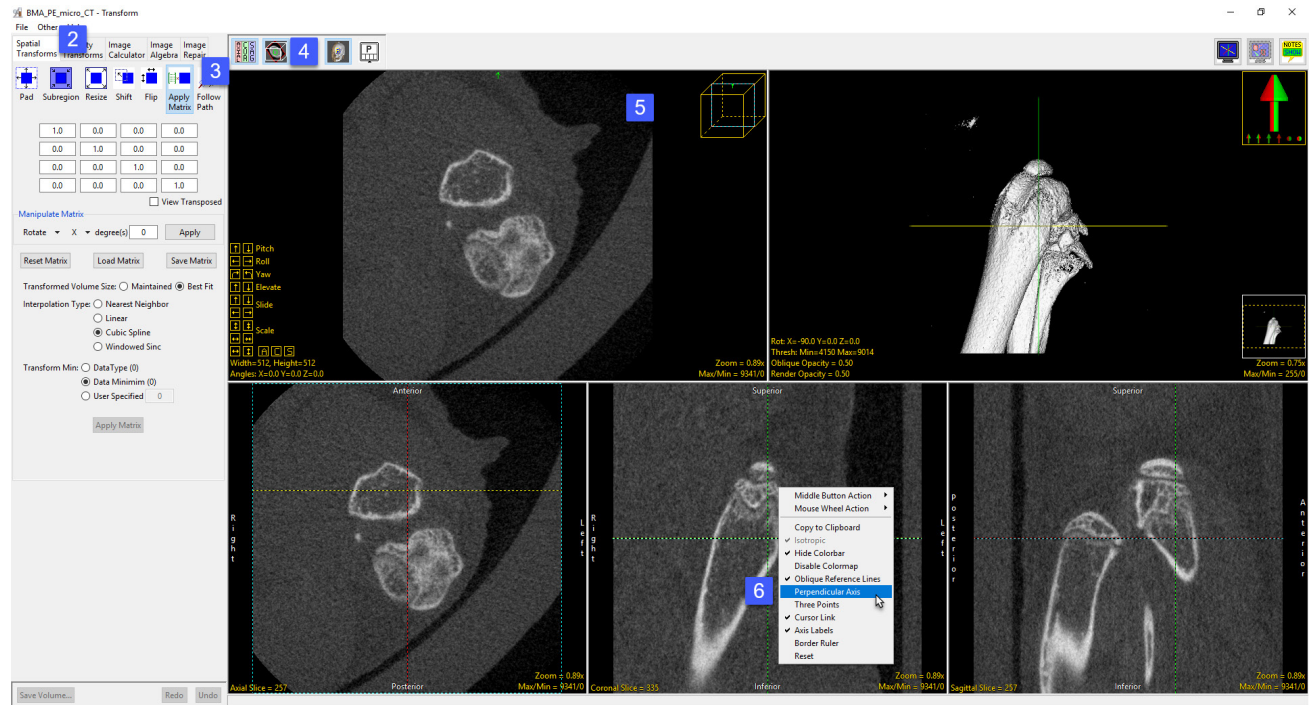
Load the data into Analyze using Input/Output.

Select the data set from the Analyze workspace and open Transform.

## Using the Apply Matrix Tool (continued)

In Transform select the Spatial Transforms tab [2] and then choose the Apply Matrix option [3]. Click the Toggle Oblique button [4] to enable to Oblique window [5].

Note, if your display does not look like that shown in the screenshot, right-click on the Controls Layout icon and choose Default Display Layout, this will return you to the standard 4 window display showing the axial, coronal, sagittal, and render displays. Now click the Toggle Oblique button. Right-click in the coronal window and select the Perpendicular Axis tool (6).



Use the Perpendicular Axis tool (red and black dashed line) [7] to define a line down the center of the bone to be analyzed. Do this by repositioning the ends of the line. In this example this is done on the coronal window. An oblique plane (shown by the blue and black dashed line) [8] will be defined perpendicular to the red and black line.



## Using the Apply Matrix Tool (continued)

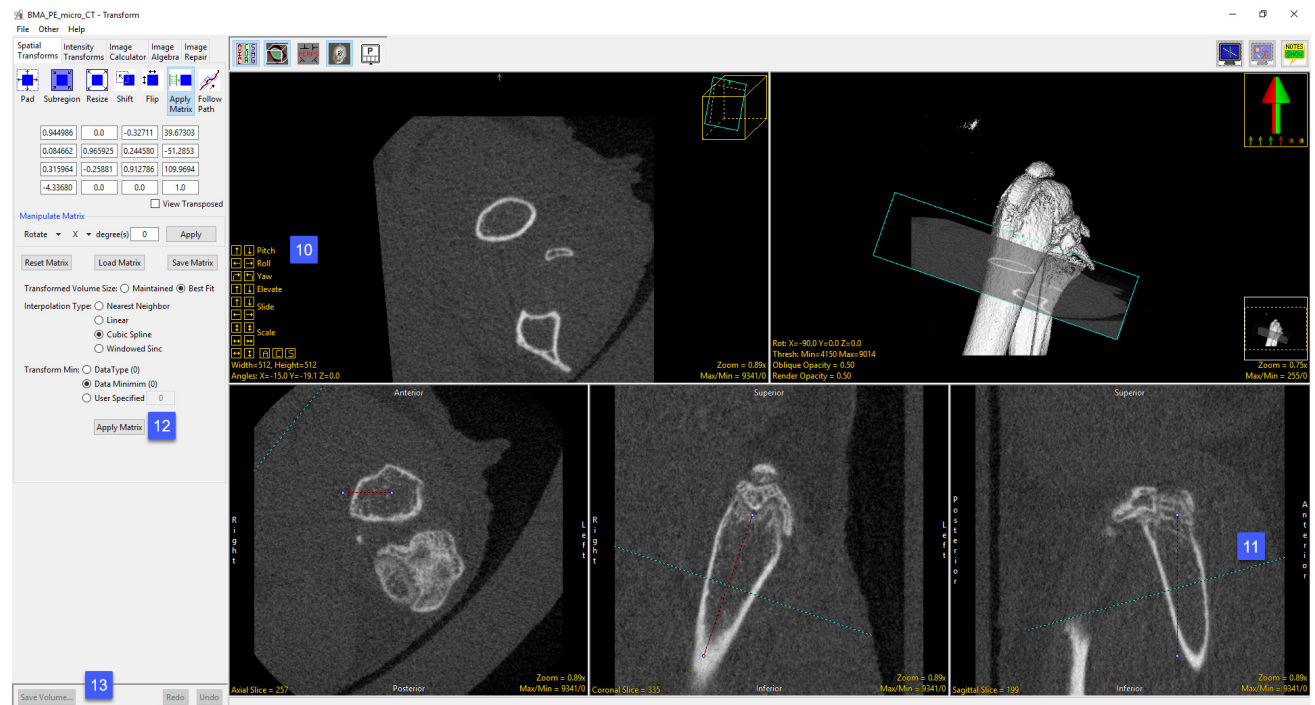
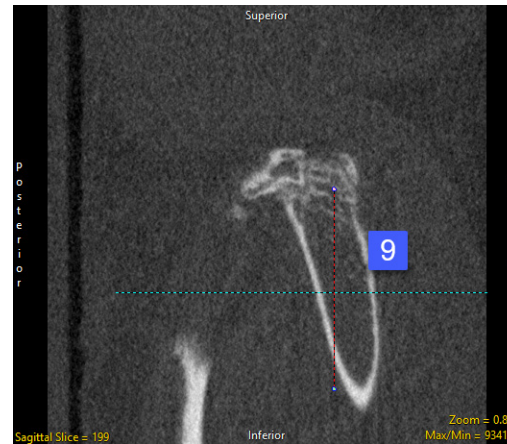
The plane will need to be adjusted in the sagittal view [9].

To do this, use the Pitch buttons in the oblique window [10] to manipulate the blue line until it is perpendicular to the long axis of the bone in the sagittal window. [11]. Note that in this example the axis (shown in blue and black on the sagittal image) should be pitched slightly upwards. This is achieved using the Pitch Up button.

To apply the transformation to the data set click the Apply Matrix button. [12]

Once the transformation is complete the data can be saved to the workspace by clicking the Save Volume button. [13]

In the Save Transformed window returned choose the 'Create a new workspace volume' option and then append '\_reformatted' to the original file name. Finally click Save Volume. The reformatted data set will be saved to the workspace.





## Follow Path

The Follow Path tool is useful for reslicing a data set along the centerline of a vessel or airway. A series of points is chosen along a path in the data set, and the data is resliced perpendicular to the line created by these points. Available options include the following.

**Path coordinates:** Users can interactively define path coordinates by clicking on and of the orthogonal display images.

- **Load:** Allows users to load a previously defined set of path coordinates.
- **Save:** Allows users to save the current path coordinates.
- **Reset:** Resets the current path coordinates.

**Intermediate Point(s):** Allows users to enable or disable the automatic intermediate points are created between users defined points:

- **None:** No intermediate points will be created.
- **Linear:** Intermediate points will be created by linear interpolation between user defined points.
- **Spine:** Intermediate points will be created by spline interpolation between user defined points.

**Image Width:** Allows users to define the width of the generated path images.

**Image Height:** Allows users to define the height of the generated path images.

**Interpolation Type:** Allows users to specify the interpolation type to be used when creating the path images. Choose from Nearest Neighbor, Bilinear, Cubic Spline, or Windowed Sinc.

**Workspace:** The workspace drop down allows users to specify which workspace the path image sequence will be saved to.

**File:** File allows users to specify the name of the path sequence.

**Preview Images:** Will display a preview of the path sequence.

**Generate Images:** Will save the path sequence to the selected workspace with the specified file name.

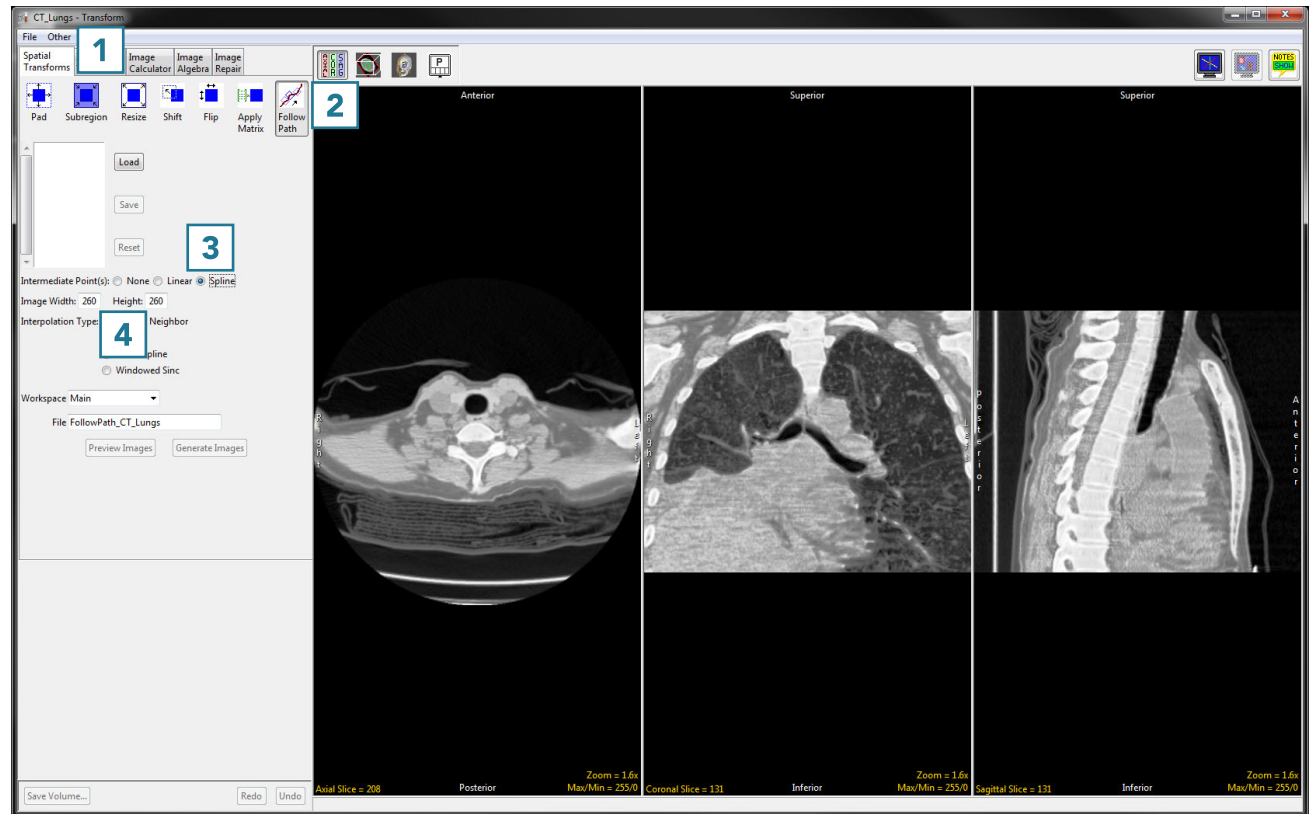
## Using the Follow Path Tool

### Reslicing Data Along the Trachea

A good example for the use of the Follow Path tools involves reslicing data along the centerline of the trachea, using lung data from CT.

To follow along, download the CT\_Lungs data set from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

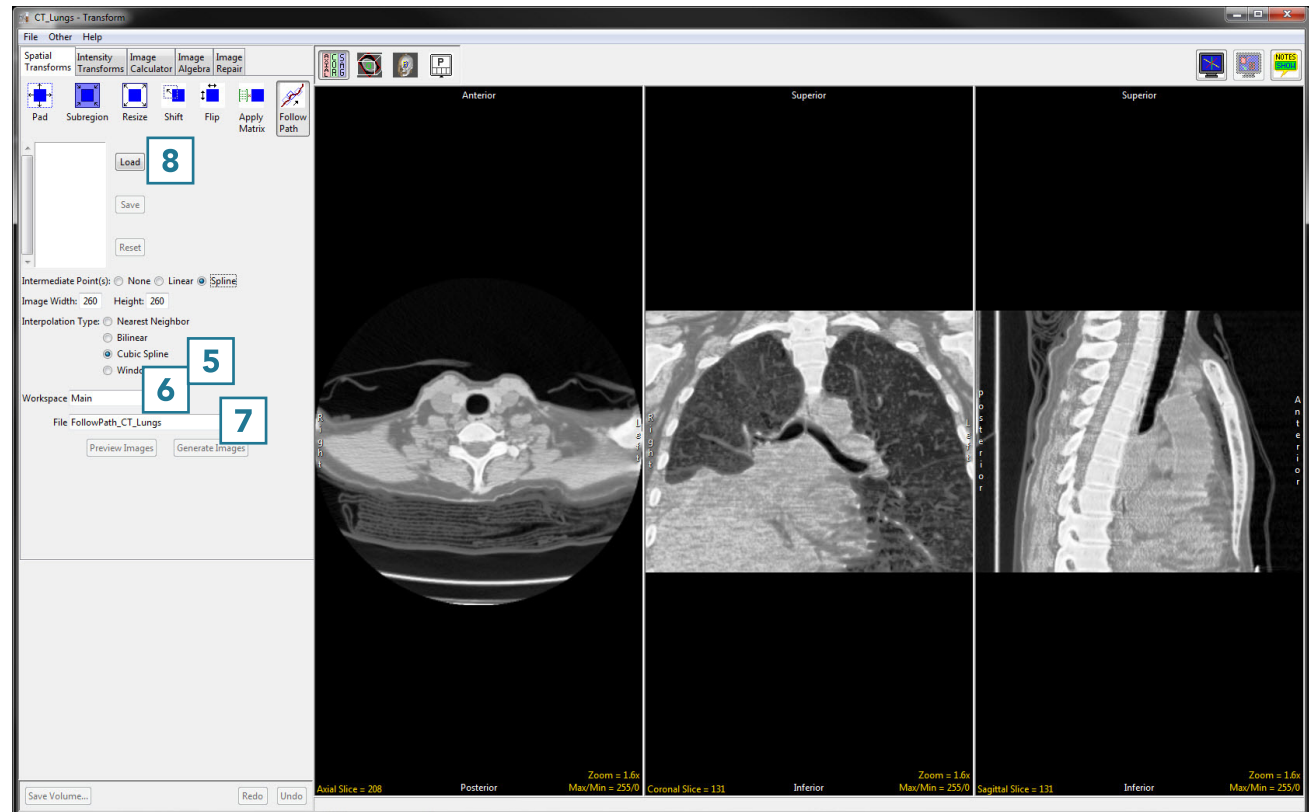
- Select the data set to reslice along a path of points and open Transform. Navigate to Spatial Transforms [1] and select the Follow Path tool [2].
- Choose a method of connecting the points: none, linear, or spline [3]. Spline creates the smoothest transition between slices, so that will be selected here.
- The image width and height [4] determine the dimensions of the output. If you are interested only in measuring the cross-sectional area of the structure on each slice, the image dimensions can be reduced from their original size.





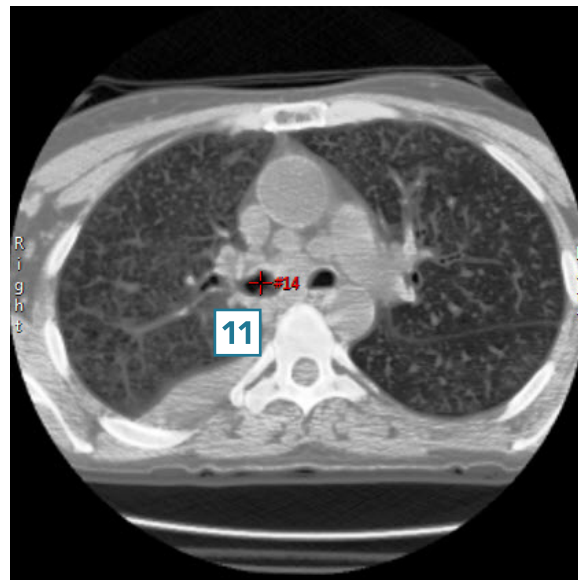
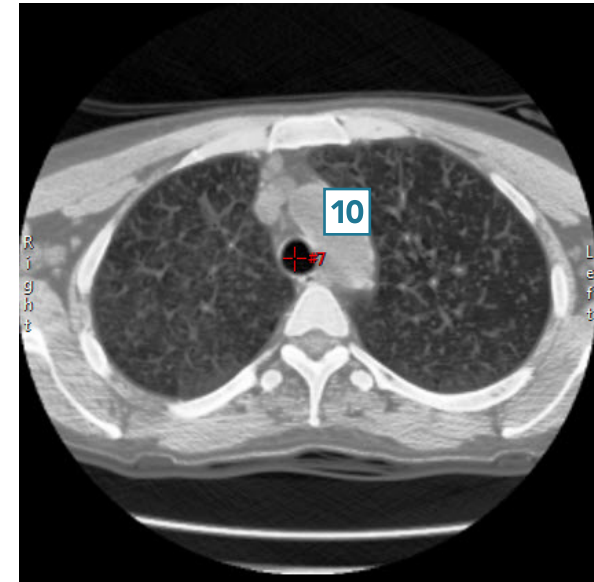
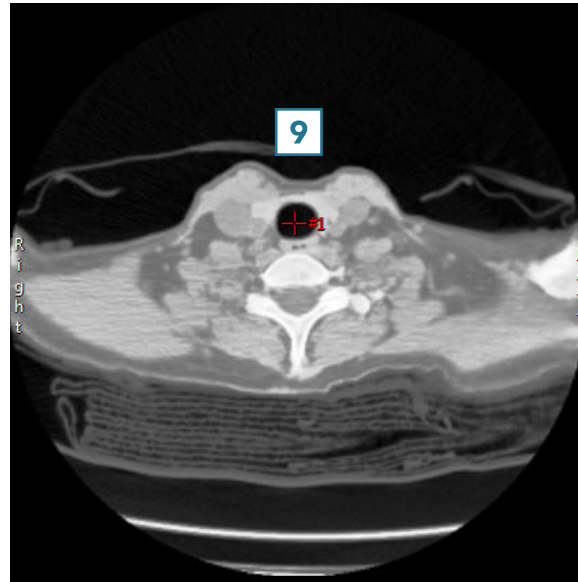
## Using the Follow Path Tool (continued)

- The interpolation type [5] can be set to nearest neighbor, bilinear, cubic spline or windowed sinc. For more information on interpolation types, see the table shown earlier in the Resize section.
- Choose a workspace [6] and output file name [7] for the resliced data set.
- Now it is time to choose the points. A previously saved set of points can be imported using the Load button [8]. Points can also be chosen by selecting them directly on the data set. Points can be chosen in any orthogonal image but must be chosen in order along a path.



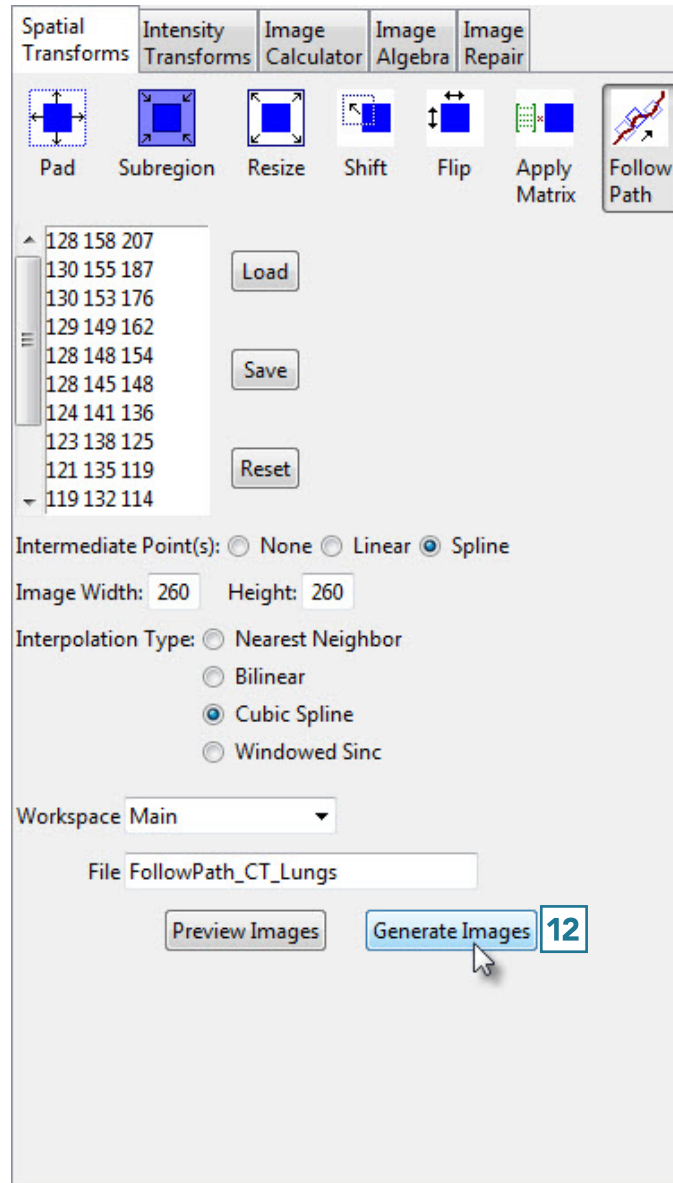
## Using the Follow Path Tool (continued)

- Click in the trachea to set the first point [9].
- Scroll through the slices and continue to set points along the path [10] until reaching the last point of the desired path [11].



## Using the Follow Path Tool (continued)

- Click Generate Images [12] to create the resliced data set and save it to the specified workspace.
- Close Transform.

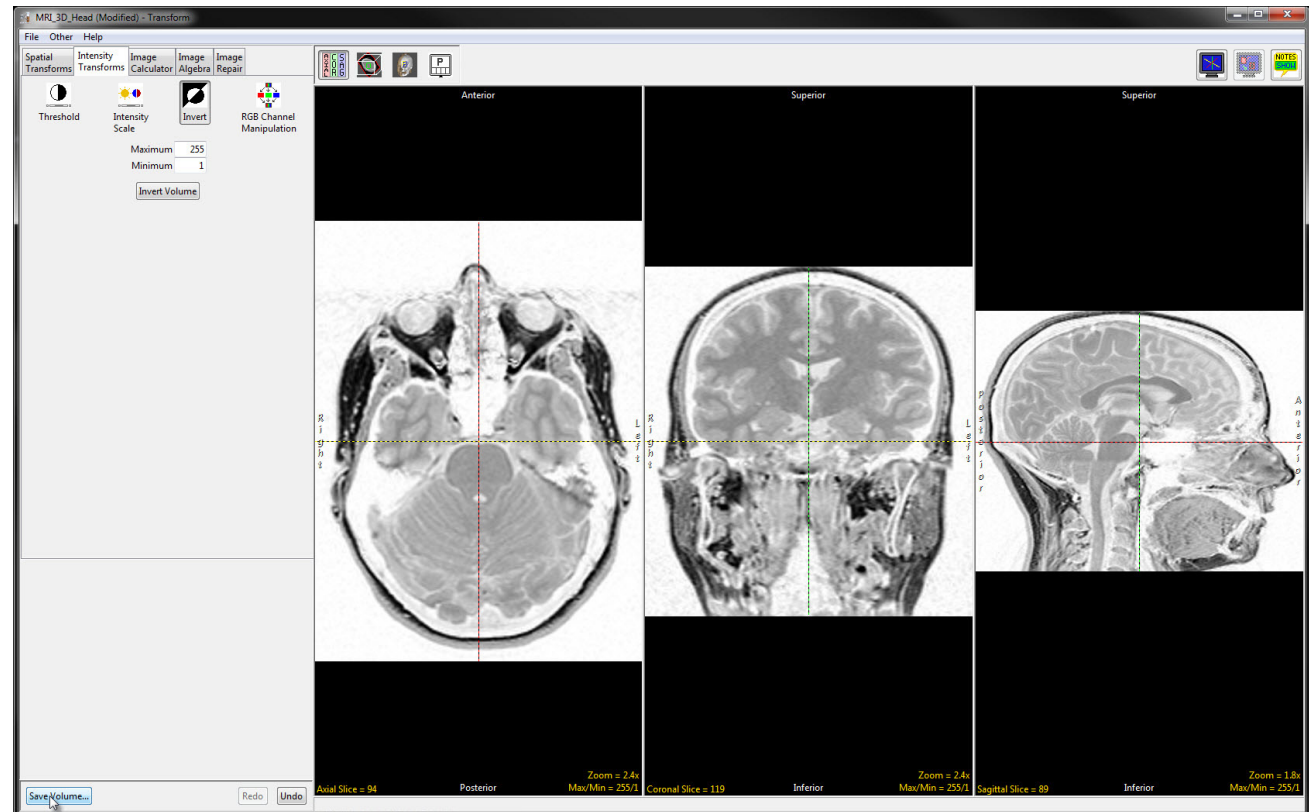


# Intensity Transforms

The Intensity Transforms tab allows access to tools that enable image intensity values to be adjusted. These would be used, for example, to make an image easier to process or to highlight certain objects within the image. The Intensity Transforms available in Analyze include:

- Threshold
- Intensity Scaling
- Inversion
- RGB channel manipulation

Many of the functions available in this section are also available in Input/Output under the Process>Intensities tab.





## Threshold

Threshold scaling allows a range of voxels from the input volume to be saved as a binary data set. All voxels greater than or equal to the threshold minimum and less than or equal to the threshold maximum are set to 1 and all other voxels are set to 0. Available options include the following:

**Threshold slider:** The Threshold double-ended slider bar allows users to specify a range of threshold values using the minimum and maximum ends of the threshold slider. Selecting the minimum end of the slider and moving it to the right will increase the minimum threshold value, moving it to the left will decrease the minimum value.

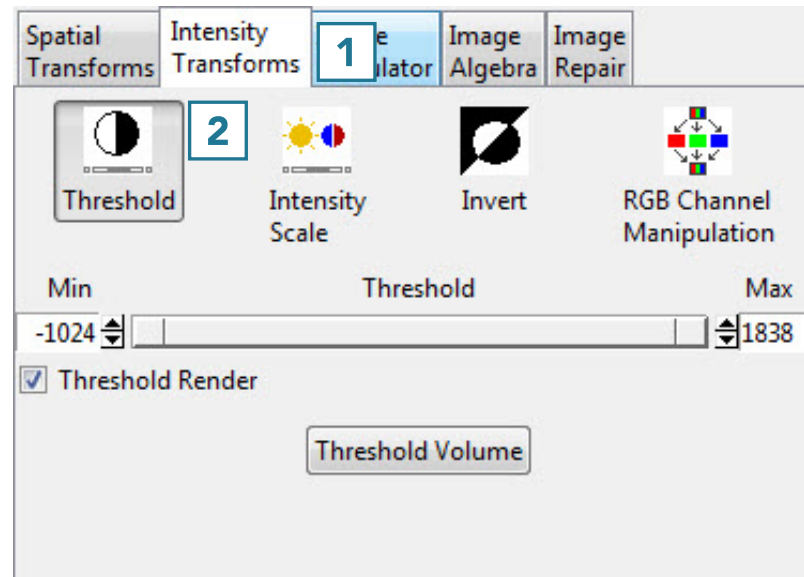
**Threshold Render:** Enables and disables the 3D threshold preview. It is recommended to disable this option for large data sets.

**Threshold Volume:** Threshold the volume data based on the minimum and maximum threshold range set using the threshold slider.

### Creating a Binary Data Set with Thresholding

To follow along, download the VHF\_Legs data set from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

Select the data set to threshold and open Transform. Navigate to Intensity Transforms [1] and select the Threshold tool [2].



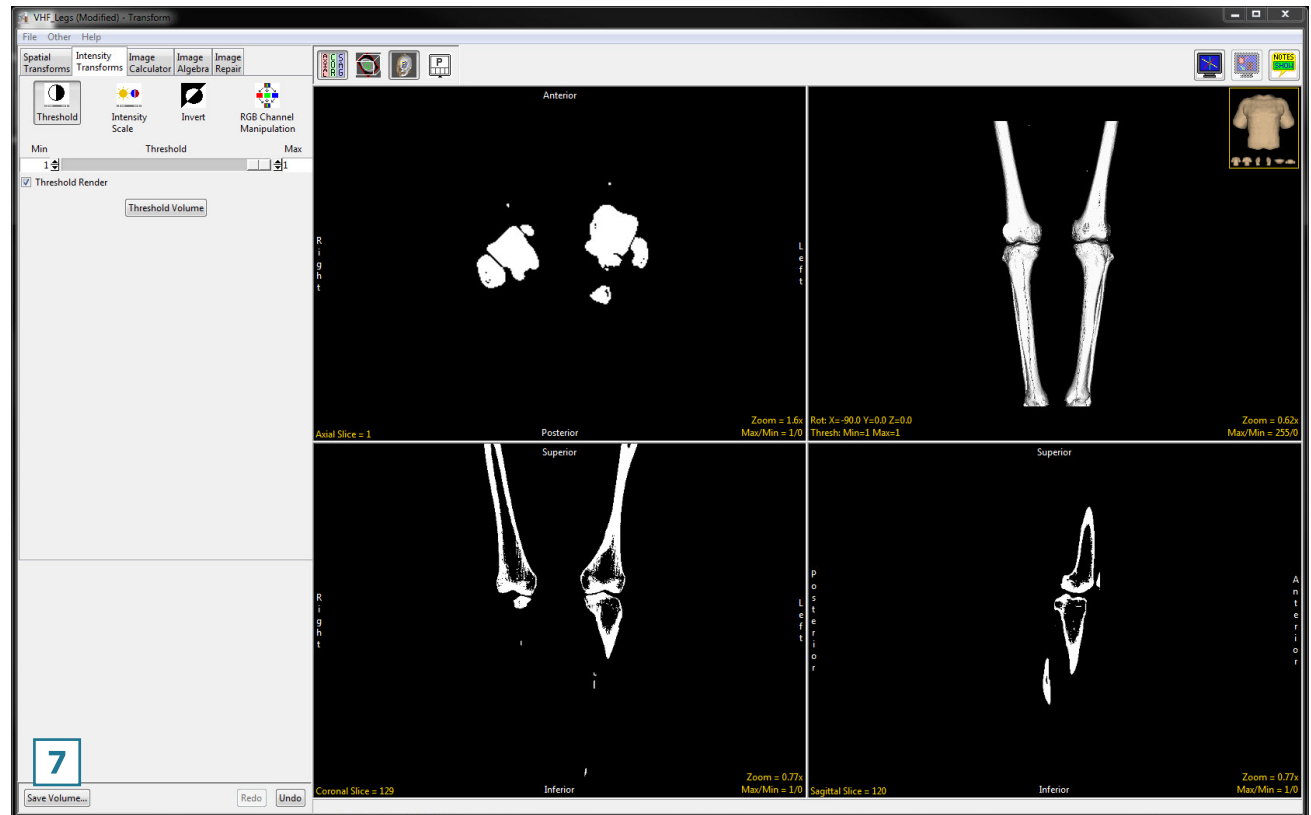
## Using the Threshold Tool (continued)

- Use the sliders to set the threshold minimum and maximum, or type the values into the input boxes [3].
- While the slider is held down, the voxels defined by the given threshold range are highlighted in red in the orthogonal views [4].
- The rendering that will result from that threshold range is shown [5].
- Click Threshold Volume [6] to apply the global threshold.

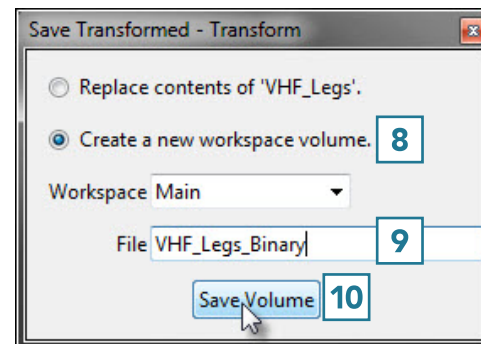


## Using the Threshold Tool (continued)

- The result is a binary data set.  
Click Save Volume [7] to save this data set.



- In the Save Transformed window, choose to create a new workspace volume [8].
- Rename [10] and click Save Volume [11].
- Close Transform.





## Intensity Scale

Intensity scaling allows for the adjustment of the voxel value information in the data. Image data can be scaled by adjusting the output data type.

Available options include the following:

**Input:** Reports the input data type and minimum and maximum intensity values.

- **DataType:** Display the input data's data type.
- **Maximum:** Displays the input data's maximum intensity value. Note, this value can be adjusted to accurately report the maximum value in the input volume.
- **Minimum:** Displays the input data's minimum intensity value. Note, this value can be adjusted to accurately report the minimum value in the input volume.

**Output:** Allows users to adjust the output data type and minimum and maximum intensity values. The following options are available:

- **DataType:** The DataType drop down menu allows users to select from the available data types, including; unsigned 8-bit, signed 8-bit, unsigned 16-bit, signed 16-bit, unsigned 32-bit, signed 32-bit, Float, RGB, and Double.
- **Maximum:** Displays the output data's maximum intensity value. This value can be adjusted.
- **Minimum:** Displays the output data's minimum intensity value. This value can be adjusted.

**Intensity Scale Volume:** Scales the data based on the intensity scaling parameters set.



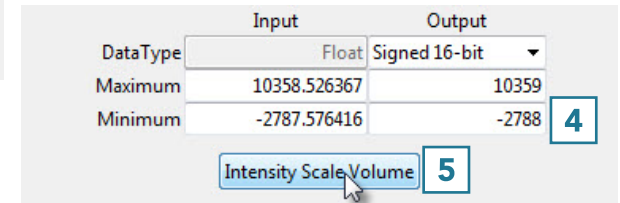
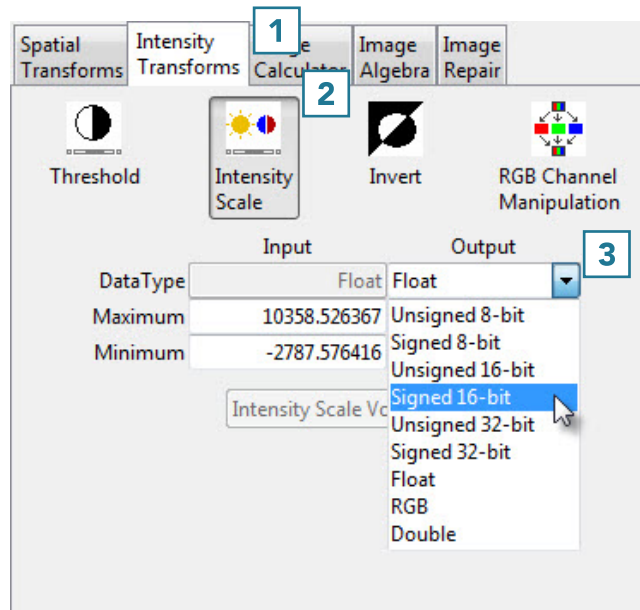
## Using the Intensity Scale Tool

### Modifying Image Data Type

Changing the data type can reduce the size of the data on disk. In this example, a microCT data set has a data type of Float and the size of the image data is 92.71 MB. Changing the data type to signed 16-bit reduces the size of the data set by about 50% to 46.35 MB without having a significant effect on the voxel intensities.

To follow along, download the Bone\_Sample\_mCT data set from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

- Select the data set to scale and open Transform.
- Navigate to Intensity Transforms [1].
- Select the Intensity Scale tool [2].
- Select the Signed 16-bit data type from the Output drop-down menu [3].



The maximum and minimum values will be set to the default values for the signed 16-bit data type.

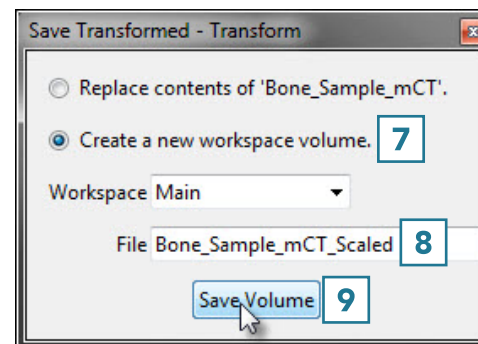
- Change these values to match the maximum and minimum input values, rounding to the nearest whole number [4].
- Click Intensity Scale Volume [5] to apply the changes.

## Using the Intensity Scale Tool (continued)

- Click Save Volume [6] to save the scaled data set.



- In the Save Transformed window, choose to create a new workspace volume [7].
- Rename the file [8].
- Click Save Volume [9].
- Close Transform.



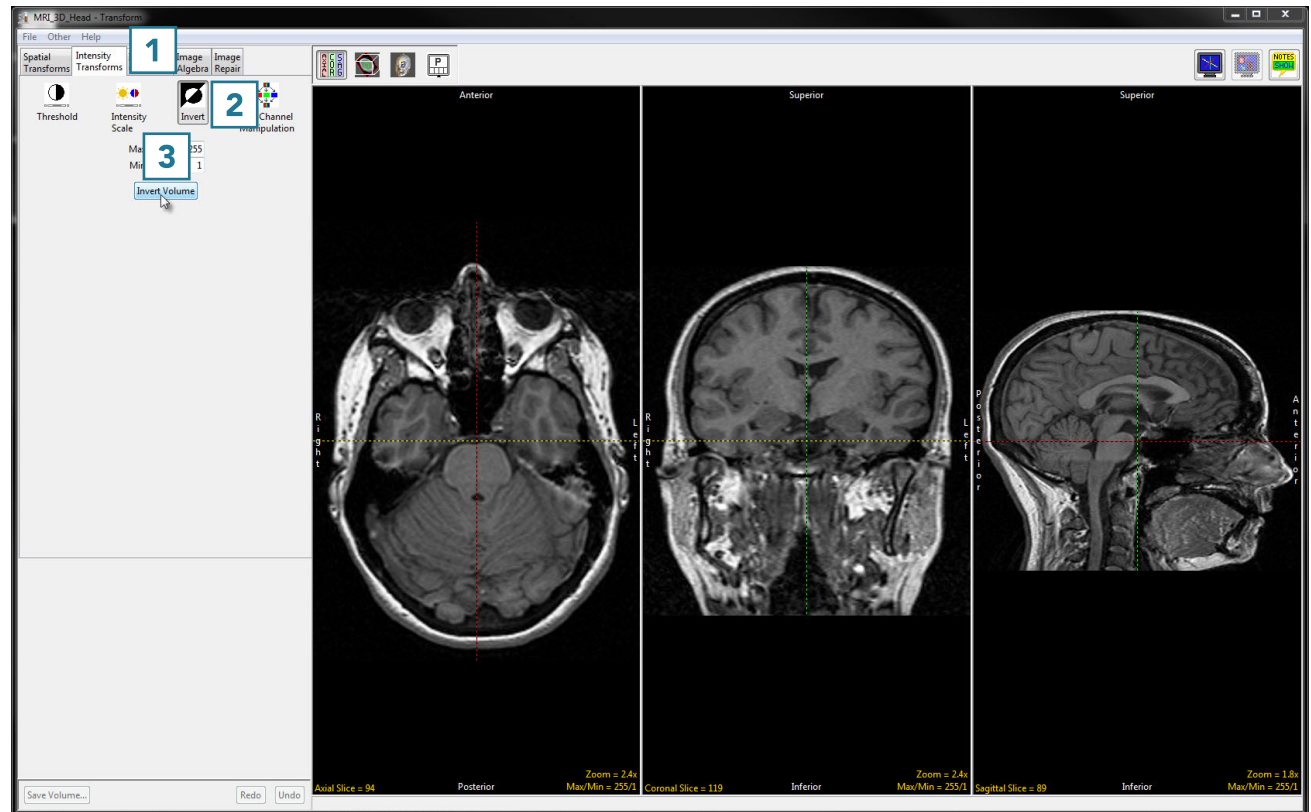
## Invert

For certain segmentation and visualization applications, it is beneficial to view an inverted copy of the image data alongside the original grayscale data. Available Options are as follows:

**Maximum:** Allows users to specify the maximum intensity value for the inverted data set.

**Minimum:** Allows users to specify the minimum intensity value for the inverted data set.

**Invert:** When selected inverts the image data.



### Inverting Data

To follow along, download the MRI\_3D\_Head data set from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

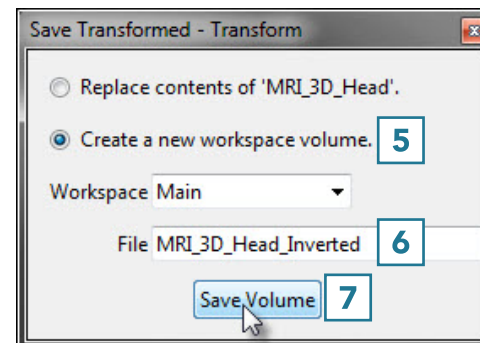
- Select the data set to invert and open Transform.
- Navigate to Intensity Transforms [1].
- Select the Invert tool [2].
- Click Invert Volume [3] to apply the inversion.

## Using the Invert Tool (continued)

- Click Save Volume [4] to save the inverted data set.

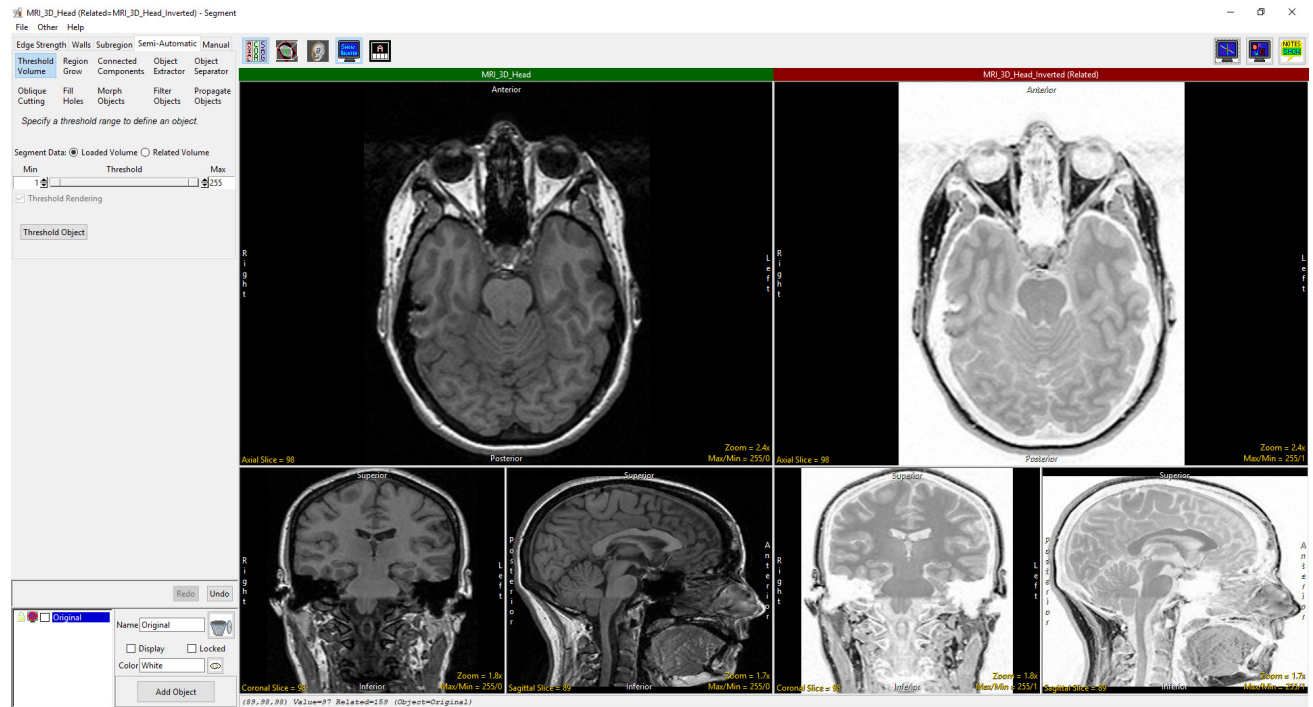


- In the Save Transformed window, choose to create a new workspace volume [5].
- Rename [6] and click Save Volume [7].
- Close Transform.



## Using the Invert Tool (continued)

- The inverse version of the input data can be useful for delineation of objects during segmentation. As the Segment module supports dual inputs, select the original MRI\_3D\_Head data set from the workspace and with the Ctrl key selected click on the inverted version just created, MRI\_3D\_Head\_Inverted, and open Segment.
- Either input can be used for the segmentation of brain structures.





## RGB Channel Manipulation

The RGB Channel Manipulation tool allows data to be converted to or from 24-bit color data. If the input is a 24-bit color file, the following options are available:

### Conversions from 24-bit Options

Option	Description
Grayscale Formula	Converts the RGB values to an 8-bit grayscale image using the following formula: $gray\_voxel = red\_voxel*.3+green\_voxel*.59+blue\_voxel*.11$
Dithering	Converts the RGB values to 8-bit with a colormap. The number of color cells used is specified by the Number Of Colors value.
Data w/Colormap	Converts the RGB values to data with a colormap using the colors in the input data
Red Channel	Specifies that only the 8-bit red channel is used for conversion
Green Channel	Specifies that only the 8-bit green channel is used for conversion
Blue Channel	Specifies that only the 8-bit blue channel is used for conversion

### Conversions to 24-bit Options

Option	Description
Data w/Colormap	Converts a data set with a colormap loaded into a 24-bit color image
Object Colored	Uses a data set and an object map to make a 24-bit data set where all the voxels have been colored using colors and definitions in the object map. Uses the following options: <b>Object Color:</b> Creates a color image displaying object color overlaid on voxels that are part of the selected objects in the object map. All other non-object voxels are removed from the image; <b>Enhanced Object Color:</b> This option is the same as the Object Color option but with enhanced (brighter) object color; <b>Object Color Only:</b> Creates a colored image representation of the grayscale image data with solid colored objects overlaid; <b>Object with Edges:</b> Creates a colored image of the grayscale data overlaid with object boundaries; <b>Object Edges Only:</b> Creates a colored image of object boundaries only; • <b>Show All Objects:</b> Uses all objects for the colored image; <b>Enabled Objects Only:</b> Uses only enabled objects for the colored image; <b>Color Enabled Only:</b> Uses only color enabled objects for the colored image.
Combine Channel(s)	Combines the red, green and blue channels into a 24-bit color image
Convert Image	Initiates the conversion process using the parameters set.

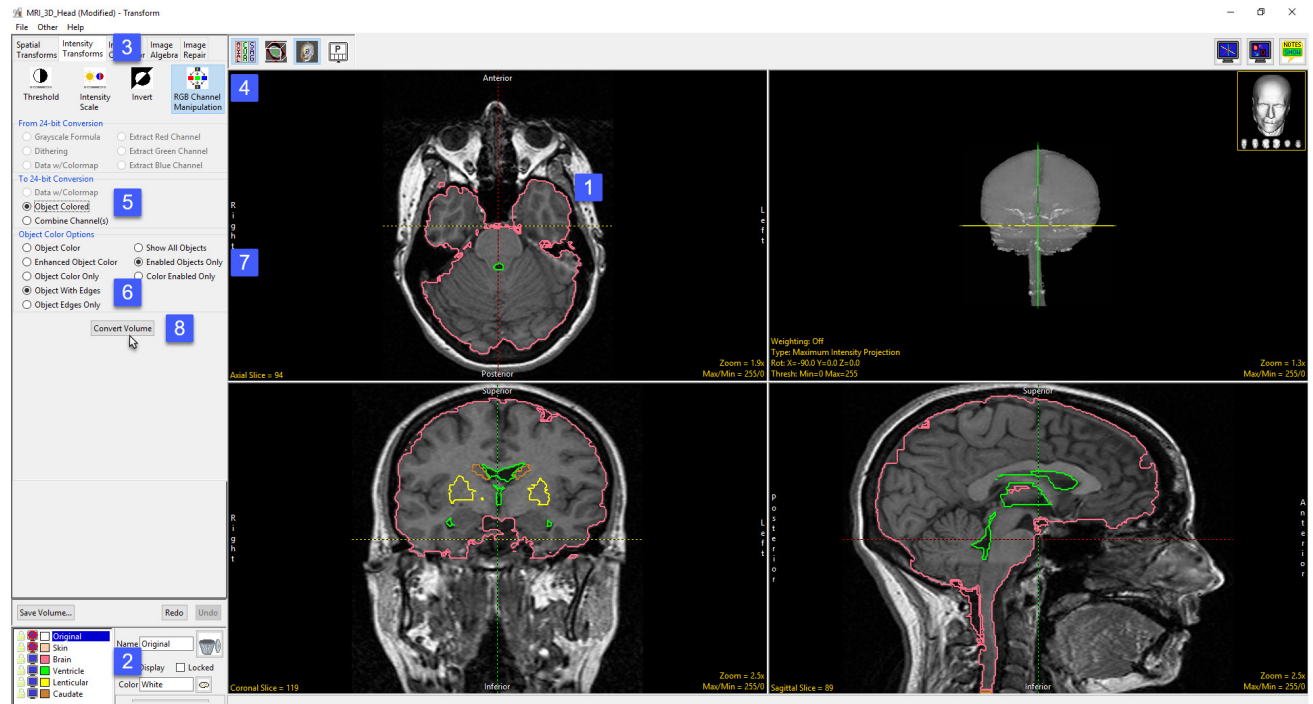
## RGB Channel Manipulation (continued)

### Creating an RGB Data Set

Creating an RGB dataset by fusing a grayscale input volume with its associated object map can provide a useful reference image.

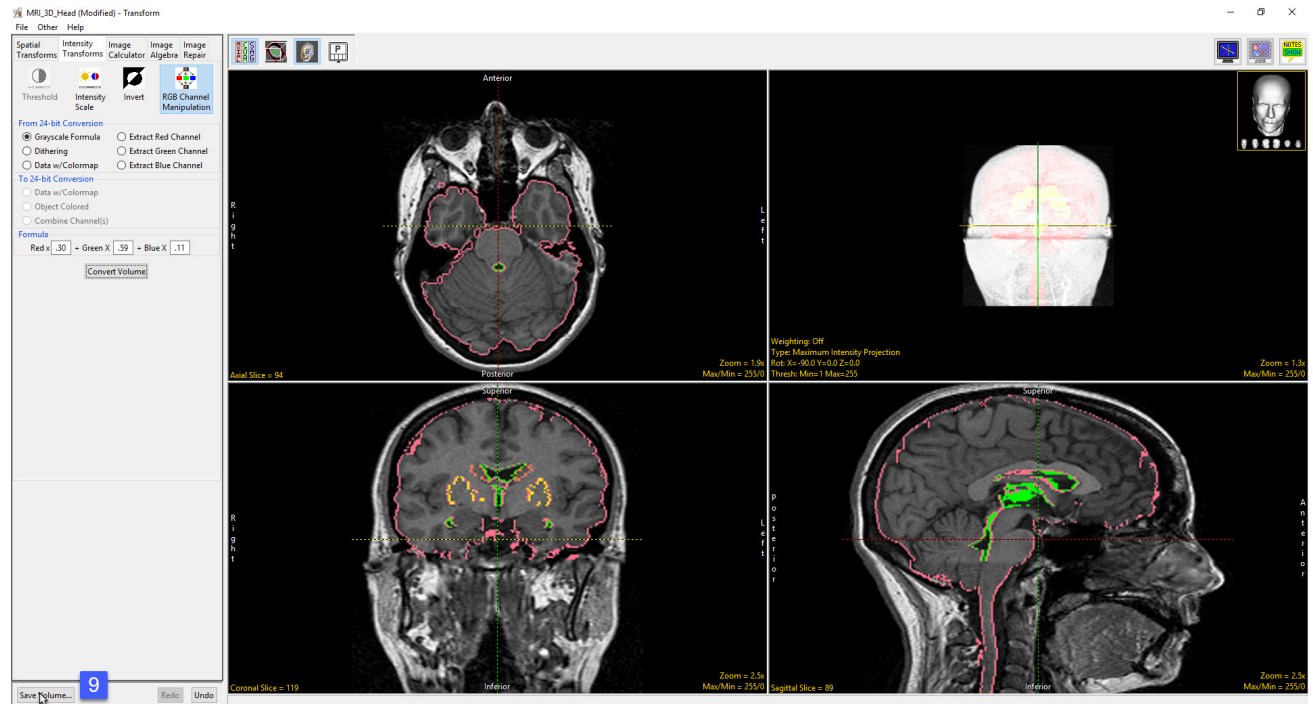
To follow along, download the MRI\_3D\_Head.awv and MRI\_3D\_Head.obj data sets from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

- Select the MRI-3D\_Head data set and open Transform.
- In Transform select File > Load Object Map and load the MRI\_3D\_Head.obj. The object map will be overlaid on the grayscale image data [1].
- In the Object control window switch Off the display of the skin object and then switch On the display of the Lenticular and Caudate objects [2].
- Select the Intensity Transformation tab [3] and then select the RGB Channel Manipulation option [4].
- Under the To 24-bit Conversion select the Object Colored option [5].
- The Object Color Options will be displayed below. Select Object With Edges [6] and then select Enabled Objects Only [7].
- Click Convert Volume [8].



## RGB Channel Manipulation (continued)

- Once the transformation is complete save the new RGB data set to the workspace using the Save Volume button [9].
- The image data can be saved out of Analyze using the Input/Output module.

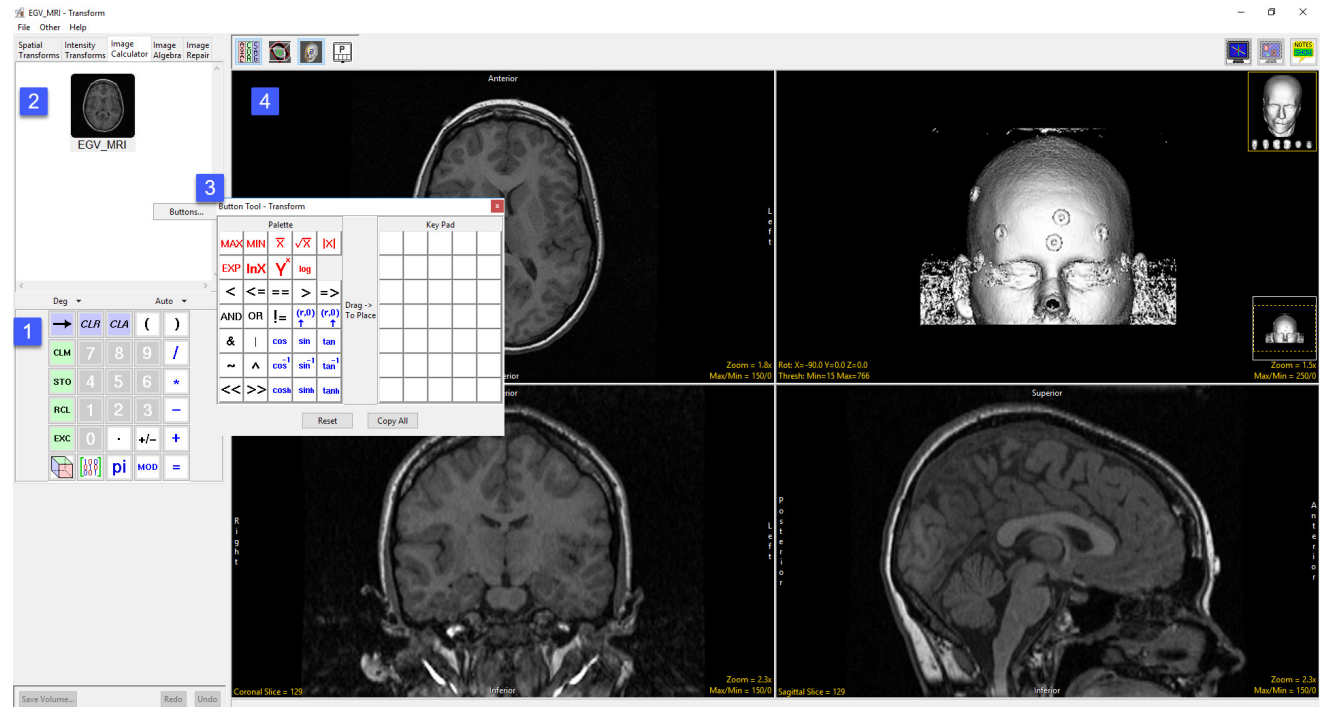




# Image Calculator

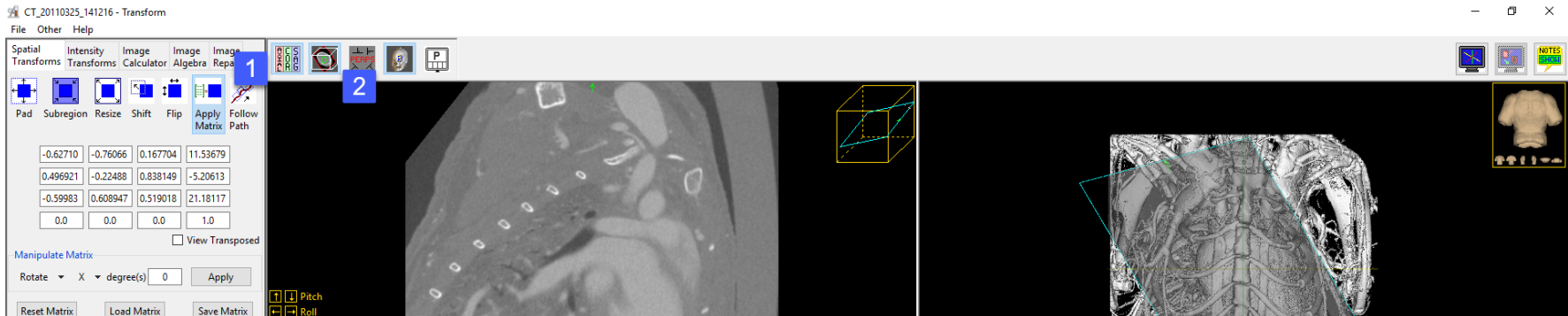
The Image Calculator tool allows many mathematical functions to be applied to volumes, matrices and constant numerical values, including basic arithmetic operations, trigonometric functions and logic operators.

The Image Calculator interface provides a keypad [1] allowing users to input functions to the calculator's scrollable canvas [2]. The canvas displaying input data, applied functions, and results. Users can also right click on the canvas to access the Buttons Tool to add additional functions to the keypad [3]. Image Calculator also provides the standard image display area [4] for data review.



## Calculator Keypad

By default, the keypad provides access to the following functions:



\*The modulo operation finds the remainder after division of one number by another.

There are also two drop-down menus available above the keys; Deg and Auto.

**Deg:** Sets the trigonometric input to Degrees, Radians, or Gradians.

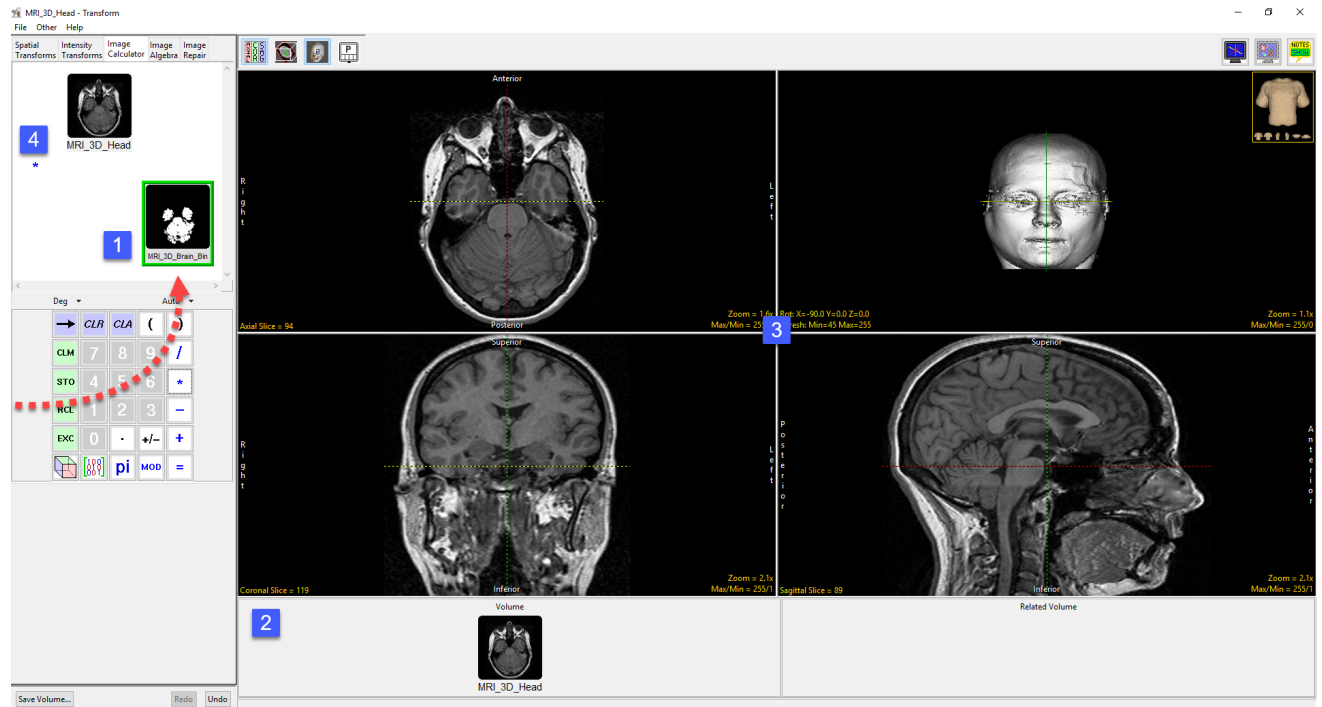
**Auto:** The Auto drop-down menu specifies how volume data will be handled during operations that may cause data overflow, for example the multiplication of two signed 16-bit data sets. The default setting, Auto, ensures that the volume data will be automatically promoted up to the next appropriate data type. In the case of the multiplication of two signed 16-bit data sets the resulting data set would have a data type of signed 32-bit. All other options will fix the calculator to work only in that data type. This means that overflow and wrapping may occur. In some instances, the data type of the volume generated may not be the type selected due to the operation and may require a specific output datatype, for example the extraction of a red channel from an RGB data set. The following data types options are available:

Unsigned 8-bit	Signed 8-bit	Unsigned 16-bit
Signed 16-bit.	Unsigned 32-bit.	Signed 32-bit.
Float	RGB	Complex

## Calculator Canvas

Data is loaded into the Image Calculator interface if a data set is selected when Transform is opened. Image Calculator also accepts image data via drag-and-drop from the workspace onto the calculator canvas [1], onto the Volume input port [2] when File > Input/Output Ports is enabled, or onto any of the display windows [3].

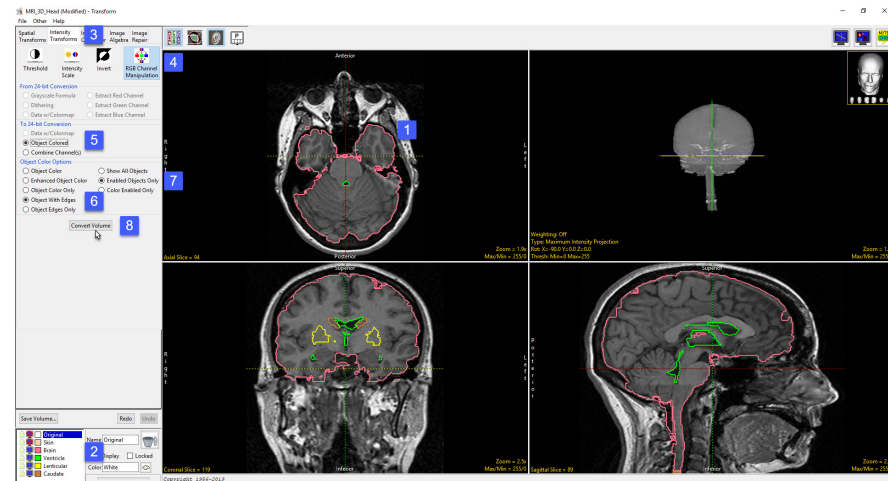
The calculator canvas also accepts matrix files loaded from disk and functions from the keypad [4].



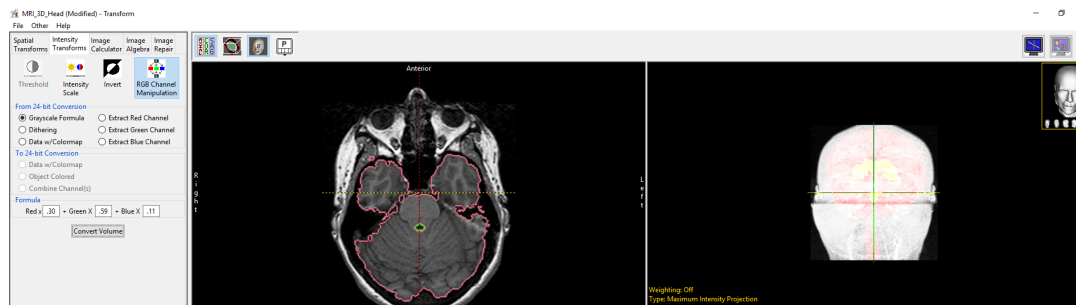
## Button Tool

Additional functions can be added to the calculator keypad. To add more functions to the keypad right click in the calculator canvas and select Buttons to open the Button Tool [1].

To add a function drag the function button from the Palette to the Key Pad [2]. The function will be automatically added to the calculator keypad [3].



The following additional functions are available:



- $\sqrt{x}$  - Square Root: returns volumes with all voxels set to their square root.
- log - log 10
- > - Greater Than
- (r,0) - Hypotenuse \*\*
- sin - Sine
- sin<sup>-1</sup> - Inverse sine
- sinh - Hyperbolic sine

- |x| - Absolute Value: Returns volumes with all voxels set to their absolute value.
- => - Greater than or equal to
- (r,0) - Atan2 \*\*\*
- tan - Tangent
- tan<sup>-1</sup> - Inverse tangent
- tanh - Hyperbolic tangent

\*\* Convert rectangular coordinates (x,y) to polar (r,0), computes magnitude r

\*\*\* Convert rectangular coordinates (x,y) to polar (r,0), computes phase 0

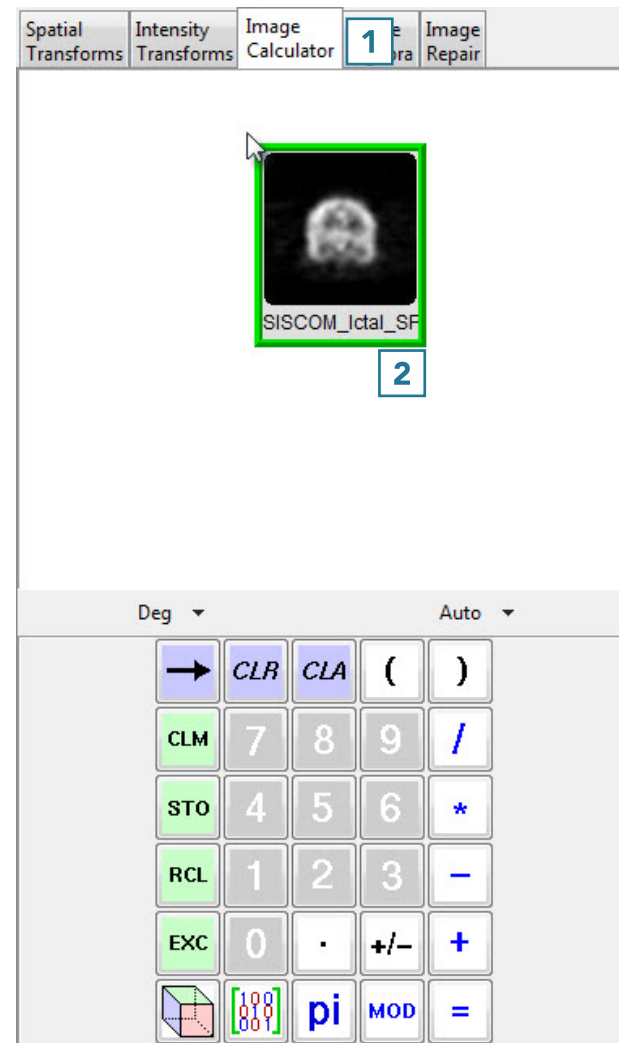
## Creating a Difference Map

A good example of Image Calculator use is in the creation of a difference map between ictal and interictal SPECT data sets, typically acquired in the study of epileptic seizures. These difference maps can be used to study regions of hypo- and hyperperfusion.

To follow along, download the SISCOM\_Ictal\_SPECT\_Nrm and SISCOM\_Interictal\_SPECT\_Coregistered\_Nrm data sets from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

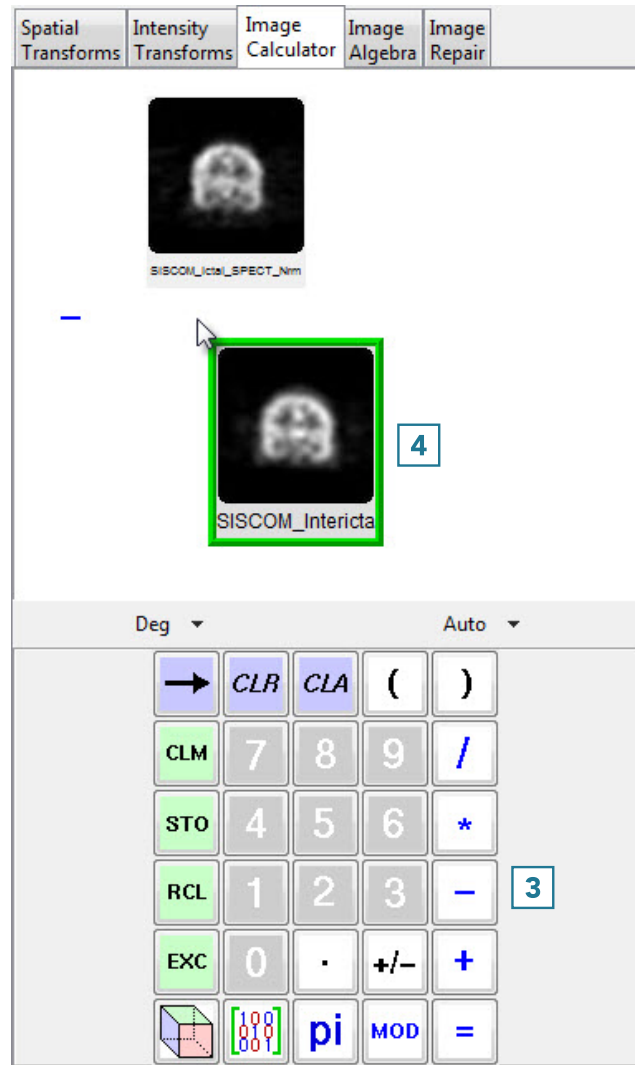
The SPECT data inputs for this exercise have already been registered and normalized so that they can be compared.

- Open Transform and navigate to Image Calculator [1].
- Drag and drop the ictal data set into the calculator window [2].

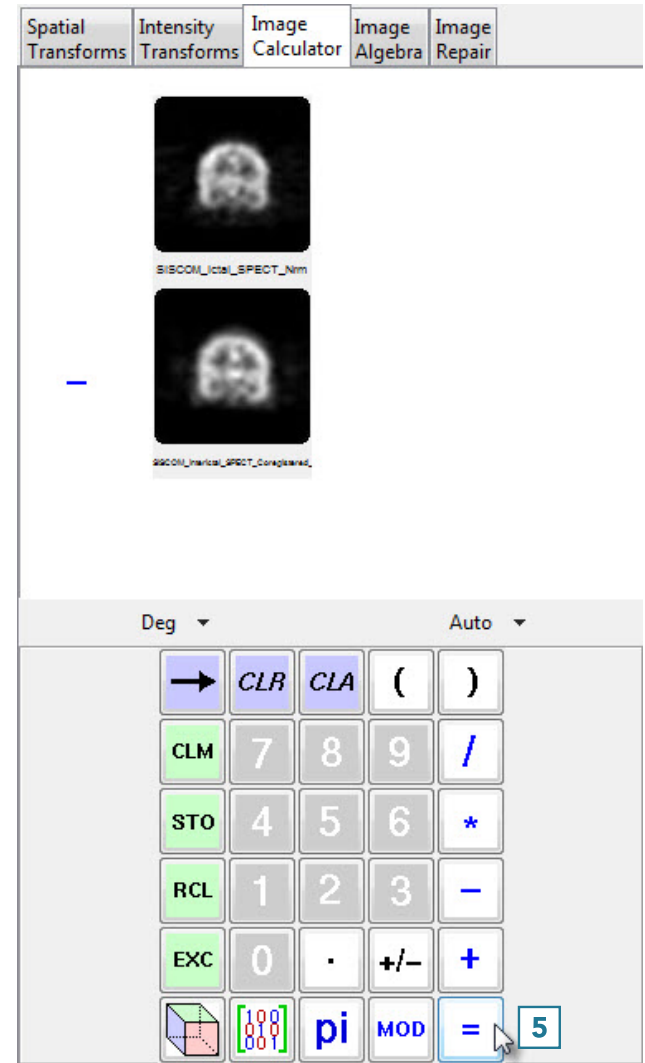


## Creating a Difference Map (continued)

- Press the minus key [3].
- Drag and drop the interictal data set into the calculator window [4].



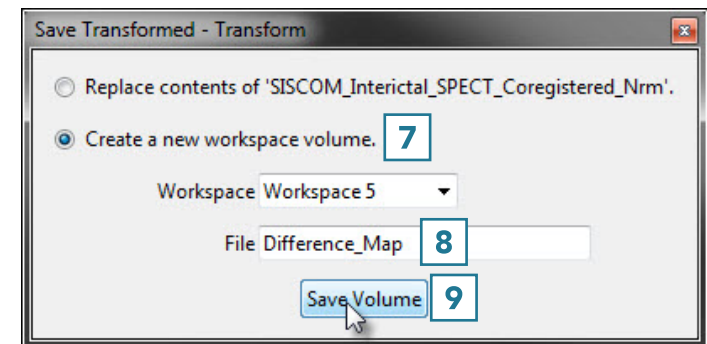
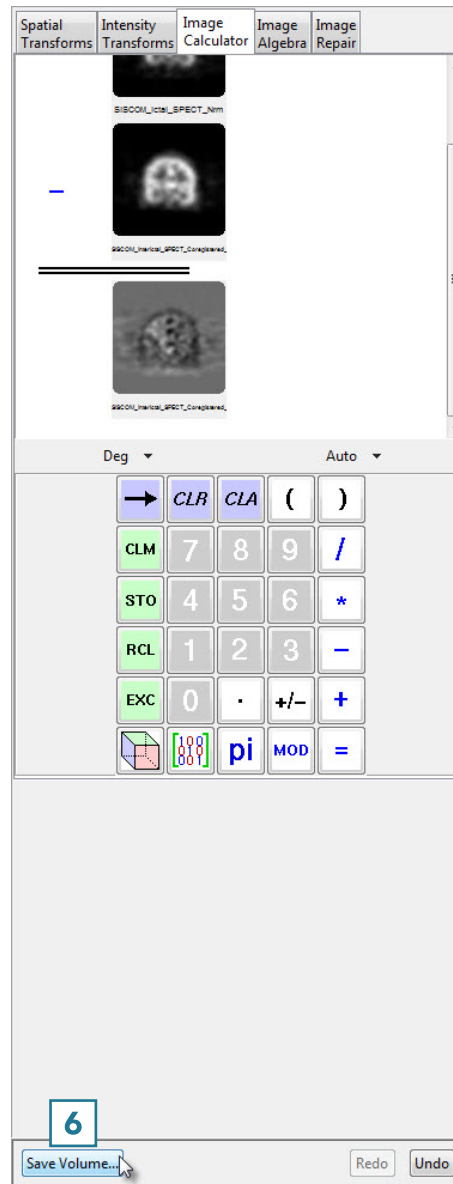
- Press the equals key [5] to complete the subtraction.



## Creating a Difference Map (continued)

- Click Save Volume [6] to save the difference map.
- In the Save Transformed window, choose to create a new workspace volume [7] and rename [8].
- Click Save Volume [9].
- Close Transform.

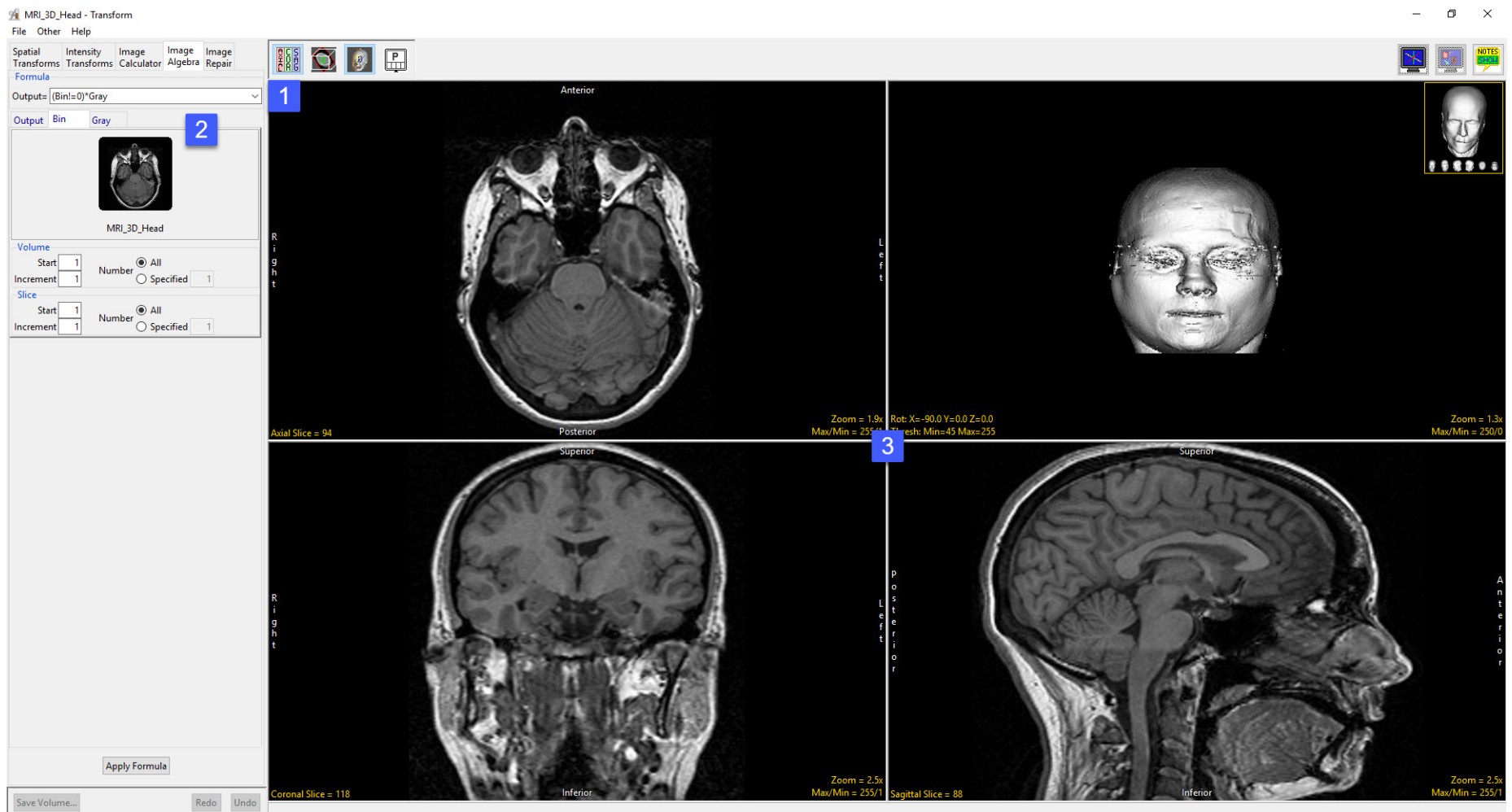
The difference map is now saved to the Analyze Workspace and is available for use in other modules.



# Image Algebra

Image Algebra performs mathematical operations on volumes and constant numerical values by means of an algebraic formula parser. There are several useful formulas preloaded, as detailed in the table below.

The Image Algebra interface provides access to a Formula parser [1], variable tabs [2], and the standard display area [3].





## Formula Parser

The Formula field allows users to enter a formula to process image data, alternatively users can choose from a list of predefined formulas.

A formula may be as simple as  $Output=Input$ , which copies a file, or as complex as to contain up to 1000 variables and 1000 constants. When entering complex formulas parenthesis should be used literally to group mathematical operations.

The following operators are supported; +, -, \*, /, ( ), <, >, <=, >=, =, !=

Symbol	Name	Meaning/Definition	Example
=	Equals sign	Equality; is equal to, equals	<b>Output = Input</b> --- Copies a file
!=	Equality operator: Inequality	Not equal to operator; is not equal to, does not equal. Returns true if the operands to not have the same value; otherwise, it returns false.	<b>Output = (Input!=145)*Input</b> Removes voxels equal to 145 from the image. '(Input!=145)' assigns all voxels not equal to 145 to 1 and all voxels equal to 145 to 0. '*Input' then multiplies the resulting binary image with the original grayscale image, all voxels assigned to 1 are kept while all voxels assigned to 0 are removed from the final image.
==	Equality operator: Equality	Equal to operator returns true (1) if both operands have the same value; otherwise it returns false (0).	<b>Output = (Mask==0)*Volume</b> Inverts the binary mask input image so all voxels set to 1 are removed from the final image while all voxels set to 0 are kept. Normally when multiplying a grayscale and binary the voxels set to 1 in the binary mask are kept while the voxels set to 0 are removed. 'Mask==0' keeps all the voxels in the binary image with a value of 0. '*Volume' multiplies the (inverted) binary image with the grayscale images, the resulting grayscale image contains the voxels that were set to 0 in the binary image.
<	Strict inequality	Less than	<b>Output = (Input&lt;155)*128</b> In this formula if the voxel intensity value is less than 155, TRUE(1) is returned and these voxels are assigned an intensity value of 128, else False(0) is returned and the result is 0 and the original grayscale value is preserved. '(Input<155)' assigns all voxels less than 145 to 1 and all other voxels to 0. '*128' then assigns all voxels with a value of TRUE(1) an intensity value of 128.

## Formula Parser (continued)

Symbol	Name	Meaning/Definition	Example
>	Strict inequality	Greater than	<p><b>Output = (Input&gt;45)*Input</b></p> <p>Keeps all voxels greater than 145 (146 and higher) in the image and removes all other voxels. '(Input&gt;145)' assigns all voxels greater than 145 to 1 and all other voxels to 0. '*Input' then multiplies the resulting binary image with the original grayscale image, all voxels assigned to 1 are kept while all voxels assigned to 0 are removed from the final image.</p>
<=	Inequality	Less than or equal to	<p><b>Output = (Input&lt;=145)*Input</b></p> <p>Keeps all voxels equal to and less than 145 in the image and removes all other voxels.</p>
>=	Inequality	Greater than or equal to	<p><b>Output = (Input&gt;=145)*Input</b></p> <p>Keeps all voxels equal to and greater than 145 in the image and removes all other voxels.</p>
+	Plus sign	Addition	<p><b>Output = File1 + File2</b></p> <p>Adds two files. Summing data is useful for averaging data for noise reduction.</p>
-	Minus sign	Subtraction	<p><b>Output = File1 - File2</b></p> <p>Subtracts File2 from File1. Subtraction is useful for creating a difference image or removing background noise.</p>
*	Asterisk	Multiplication	<p><b>Output = Binary*Grayscale</b></p> <p>Multiplies two data sets, in this example the binary image is multiplied by a grayscale image. All voxels in the binary mask equal to 1 will be kept in the resulting grayscale image while all voxels with a value of 0 will be removed. Useful for masking data.</p>
/	Division slash	Division	<p><b>Output = (File1+File2)/2</b></p> <p>Averages 2 data sets. Useful for averaging images to reduce noise.</p>
()	Parentheses	Calculate expression inside first	<p><b>Output = (Input-intercept)/slope</b></p> <p>Scales image data based on the slope and intercept values from a linear regression line. Useful for rescaling CT data to HU's or BMD units. '(Input-intercept)' minuses the intercept value from the input value prior to dividing by the slope '/slope'.</p>

## Formula Parser (continued)

### Application examples:

**Data Normalization:**  $\text{Output} = (\text{input} - (\min(\text{input}))) / (\max(\text{input}) - (\min(\text{input})))$

**Scaling data to a phantom:**  $\text{Output} = (\text{Input} - \# \text{intercept} \#) / \# \text{slope} \#$

**Masking data and setting the excluded voxels to a specific intensity value:**  $\text{Output} = (\text{Mask} == 0) * \text{Volume} + (\text{Mask} == 1) * \# \text{value} \#$

The following functions are supported:

Function	Notes
sqrt(equation)	Equation can be a variable or a constant.
log(equation)	Equation can be a variable or a constant.
exp(equation)	Equation can be a variable or a constant.
count()	Returns the output slice number.
max(variable)	Returns the maximum value.
min(variable)	Returns the minimum value.
avg(variable)	Returns the average value.
abs(variable)	Returns absolute value.
int(variable)	Converts to integer, truncating floating point values.
float(variable)	Converts to floating point values.
xpos()	Returns the x position in the input image.
ypos()	Returns the y position in the input image.
ADDTOT(num_add, inc)	Returns the sum of the added images as a floating point image.
ADDAVG(num_add, inc)	Returns the result of the added and averaged images.
RED(variable)	Returns the red portion of the RGB image if the variable specifies an RGB image or an image with a colormap.
GREEN(variable)	Returns the green portion of the RGB image if the variable specifies an RGB image or an image with a colormap.
BLUE(variable)	Returns the blue portion of the RGB image if the variable specifies an RGB image or an image with a colormap.

Note: **ADDTOT()** and **ADDAVG()** are specialized functions that allow large groups of images to be summed or averaged. Unlike other functions which use a single image as input, these functions allow for multiple image inputs, with a single output image generated. The options in the variables menu all users to specify which input image is passed to a function. With these functions, the values specified in the variables menu specify only the starting slice for a group of images. num\_add specifies the total number of images to add together, and inc specifies the increment between these images. Special status messages are generated when these functions are executed. Review these messages carefully if you experience problems accomplishing the desired total and averaging functions.

## Formula Parser (continued)

### Additional information when defining formulas:

- Surrounding variables with #'s, will cause prompting for the information that is to be put in the formula in place of the variables.
- Variable names must begin with an alpha character and have no more than 15 alphanumeric characters.
- <, >, <=, >=, ==, != are boolean operators that can be used in user specified formulas. The following is an example showing the use of boolean operators:

There are several useful formulas preloaded, as detailed in the table below.

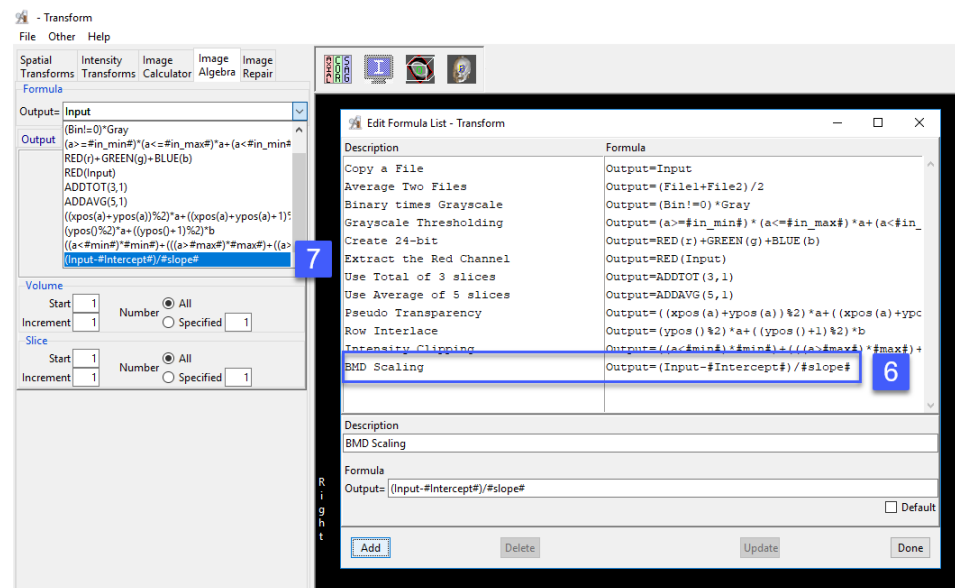
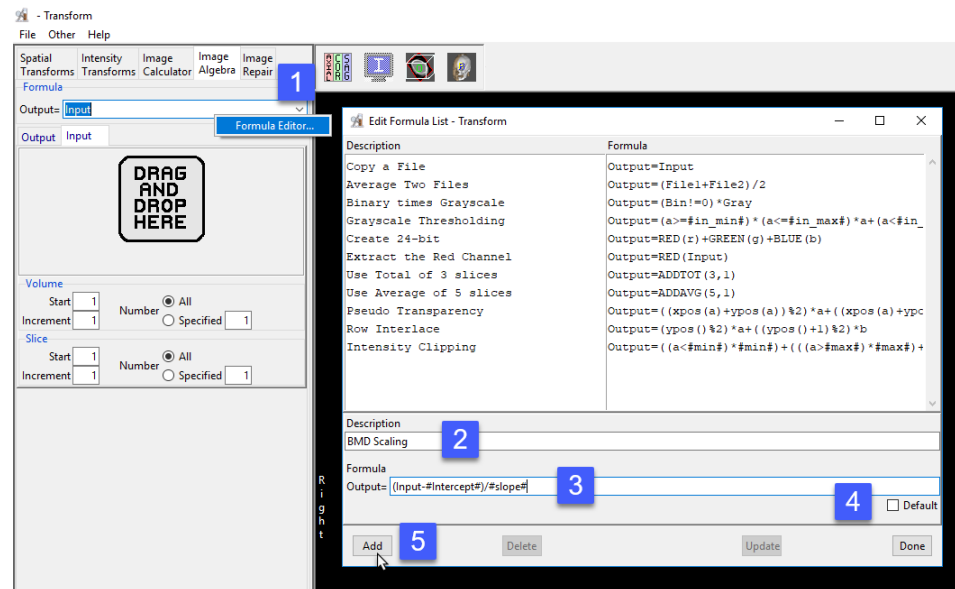
Formula	Output=
Copy a File	Input
Average Two Files	(File1+File2)/2
Binary times Grayscale	(Bin!=0)*Gray
Grayscale Thresholding	(a>=#in_min#)*(a<=#in_max#)*a+(a<=#in_min#)*#out_min#+(a>=#in_max#)*#out_max#
Create 24-bit	RED(r)+GREEN(g)+BLUE(b)
Extract the Red Channel	RED(Input)
Use Total of 3 slices	ADDTOT(3,1)
Use Average of 5 slices	ADDAVG(5,1)
Pseudo Transparency	((xpos(a)+ypos(a))%2)*a+((xpos(a)+ypos(a)+1)%2)*b
Row Interlace	(ypos()%2)*a+((ypos()+1)%2)*b
Intensity Clipping	((a<=#min#)*#min#)+(((a>#max#)*#max#)+((a>=#min#)*(a<=#max#))*a)

## Formula Parser (continued)

### Adding Formulas

To add your own formula to the list of formulas available from the formula drop down menu, do the following.

- Right click in the Formula field [1].
- In the Edit Formula List window returned enter a description for your formula [2].
- Next, enter the formula [3]. Remember to surround variables with #'s to make them imputable.
- Uncheck the Default option [4], unless you wish your formula to be the default formula that appears in the formula bar when Image Algebra is selected.
- Click Add [5].
- The formula will be added to the list [6] and will be selectable from the formula drop down menu [7].
- Apply Formula: Applies the formula to the image data.
- Save Volume: Opens the Save Transform window

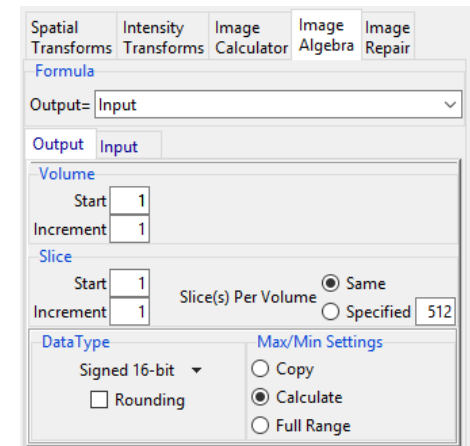


## Variables

Variables are dynamically generated when a formula is created or selected. The entries allow for the specification and/or modification of data values and parameters. Should a parameter fail to be provided and a default value cannot be determined, the formula parser will prompt the user for the value. The following options are available (depending on the current formula):

**Output:** allows for the specification of the output image attributes. The following options are available:

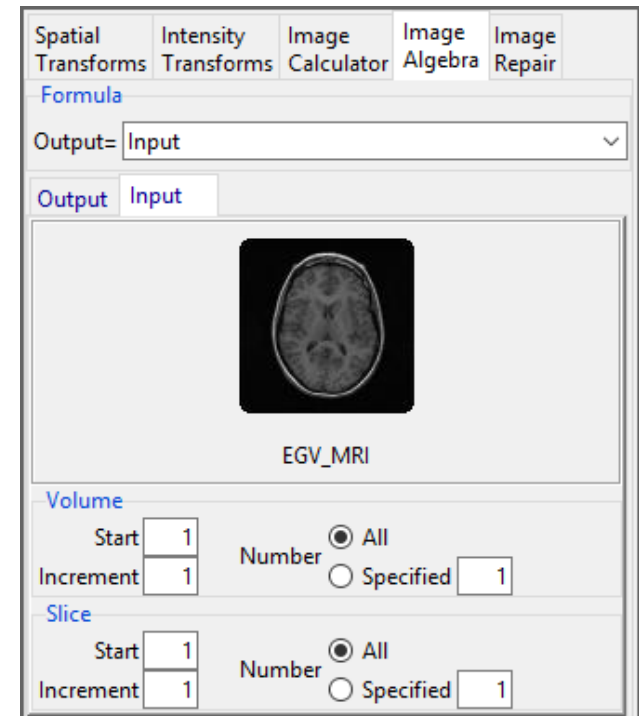
- Volume: The volume field enables specification of the volume attributes for the output file
  - Start: Specifies the starting volume number for the output file.
  - Increment: Specifies the increment used between volumes for the output file.
- Slice: The slice field enables specification of the slice attributes for the output file.
  - Start: Specifies the starting slice number in the output volume for each volume processed.
  - Increment: Specifies the increment between slices for the output volume.
  - Slice(s) Per Volume: Specifies the number of slices in each output volume. Options are: *Same*: When selected, indicates that the number of slices in the first input file is used as the number of slices in the output file; *Specified*: When selected, enables the specification of the number of slices in the output file.
- DataType: Specifies the data type of the output file. Users can choose from a list of available data types, including; unsigned 8-bit, signed 8-bit, unsigned 16-bit, signed 16-bit, unsigned 32-bit, signed 32-bit, float, RGB, and double.
  - Rounding: When enabled, floating values are converted to integers by rounding to the nearest integer, otherwise the number will be truncation at the decimal point. This option has no effect if the calculated value is an integer or the Output Datatype is float.
- Max/Min: Specifies the method used to set the maximum and minimum values for the output file. The following options are available:
  - Copy: Specifies that the maximum and minimum values are copied from the input file.
  - Calculate: Specifies that the maximum and minimum values are calculated for every slice processed.
  - Full Range: Specifies that the maximum and minimum are set to the full range possible for the current data type.



## Variables (continued)

**Variable:** The variable parameters, named assigned from the variable defined in the formula, allows for the specification of the variable (e.g. Input) volume attributes. The following options are available:

- Volume: The Volume field enables specification of the volume attributes for the variable volume.
  - Start: Specifies the starting volume number for the variable volume.
  - Increment: Specifies the increment used between volumes for the variable volume.
  - Number: Choose from the following to specify the number of volumes to be processed:
    - All*: Specifies that all volumes in the variable volume will be processed;
    - Specified*: Indicates the number of volumes in the variable volume to be processed.
- Slice: The slice field enables specification of the slice attributes for the variable volume.
  - Start: Specifies the starting slice number in the variable volume for each volume processed.
  - Increment: Specifies the increment between slices for the variable volume.
  - Number: Choose from the following to specify the number of slices to be processed: *All*: Specifies that all slices in the variable volume will be processed; *Specified*: Indicates the number of slices in the variable volume to be processed.

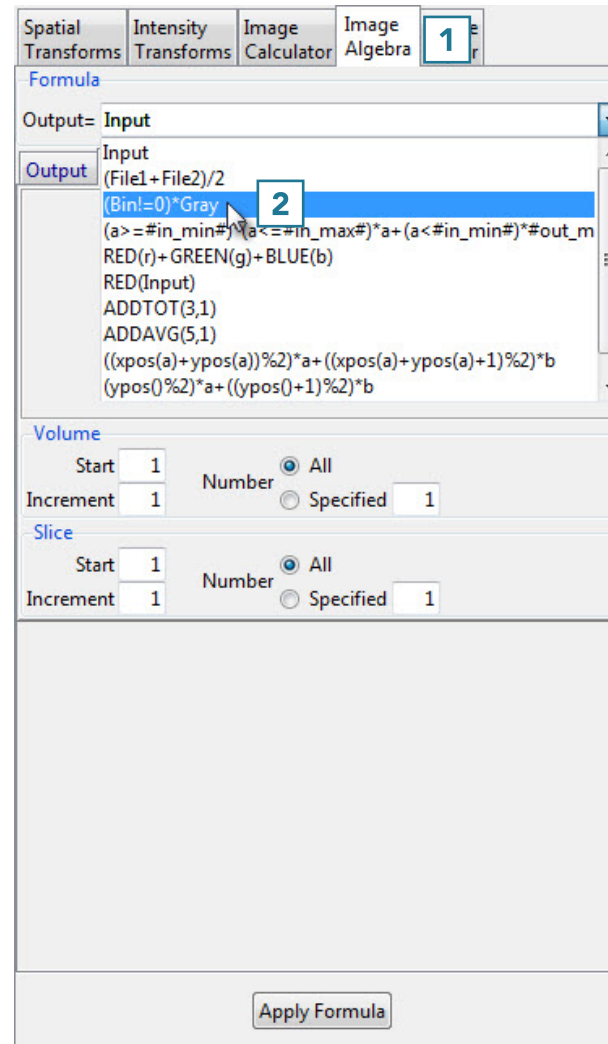


## Applying a Binary Mask to a Grayscale Volume

A good example of Image Algebra use involves multiplying a grayscale data set with a binary data set. The binary brain will act as a mask; all voxels in the grayscale data set that fall within the binary mask will be kept, while the voxels that fall outside will be removed.

To follow along, download the MRI\_3D\_Head and MRI\_3D\_Head\_Bin data sets from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

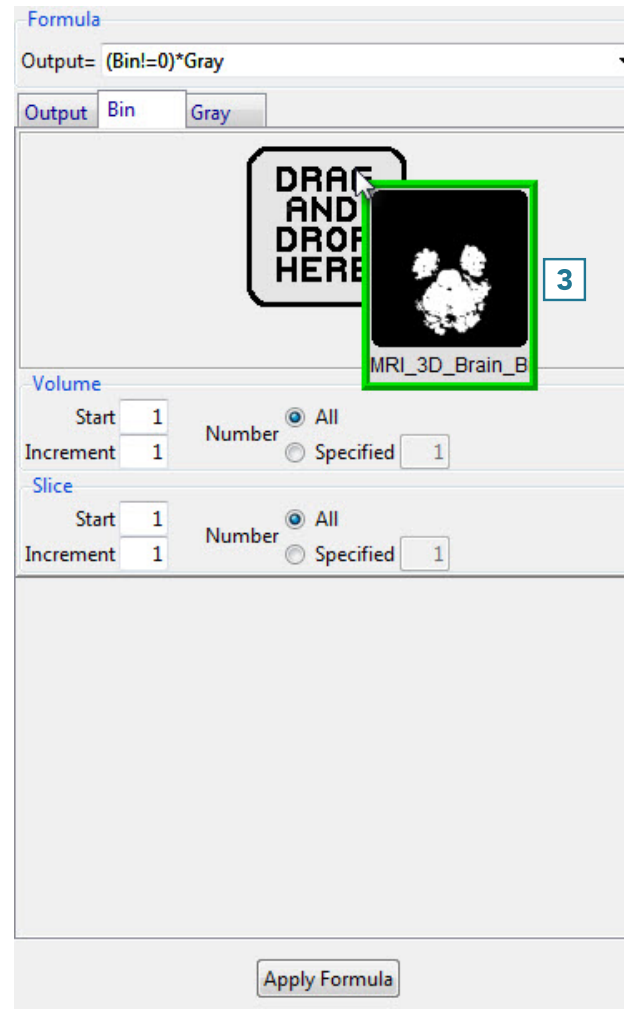
- Open Transform and navigate to Image Algebra [1].
- From the formula drop-down, select the third option down: (Bin!=0)\*Gray [2].



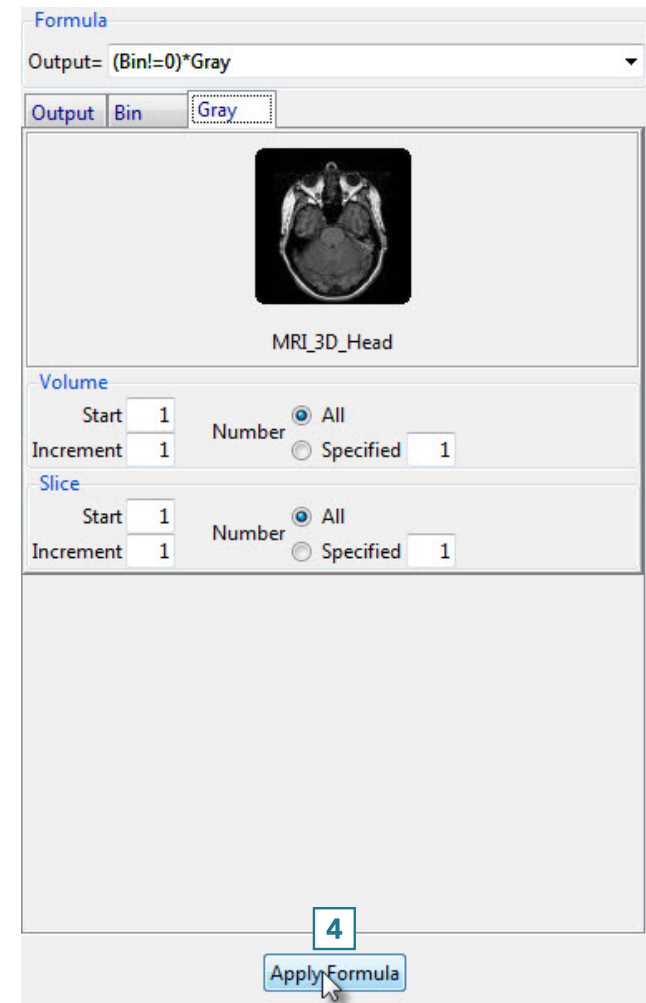


## Applying a Binary Mask to a Grayscale Volume (continued)

- The input variables will appear as tabs labeled with the variable names.
- Drag and drop the binary data set into the designated space on the Bin tab [3].
- Do the same with the grayscale data set on the Gray tab.

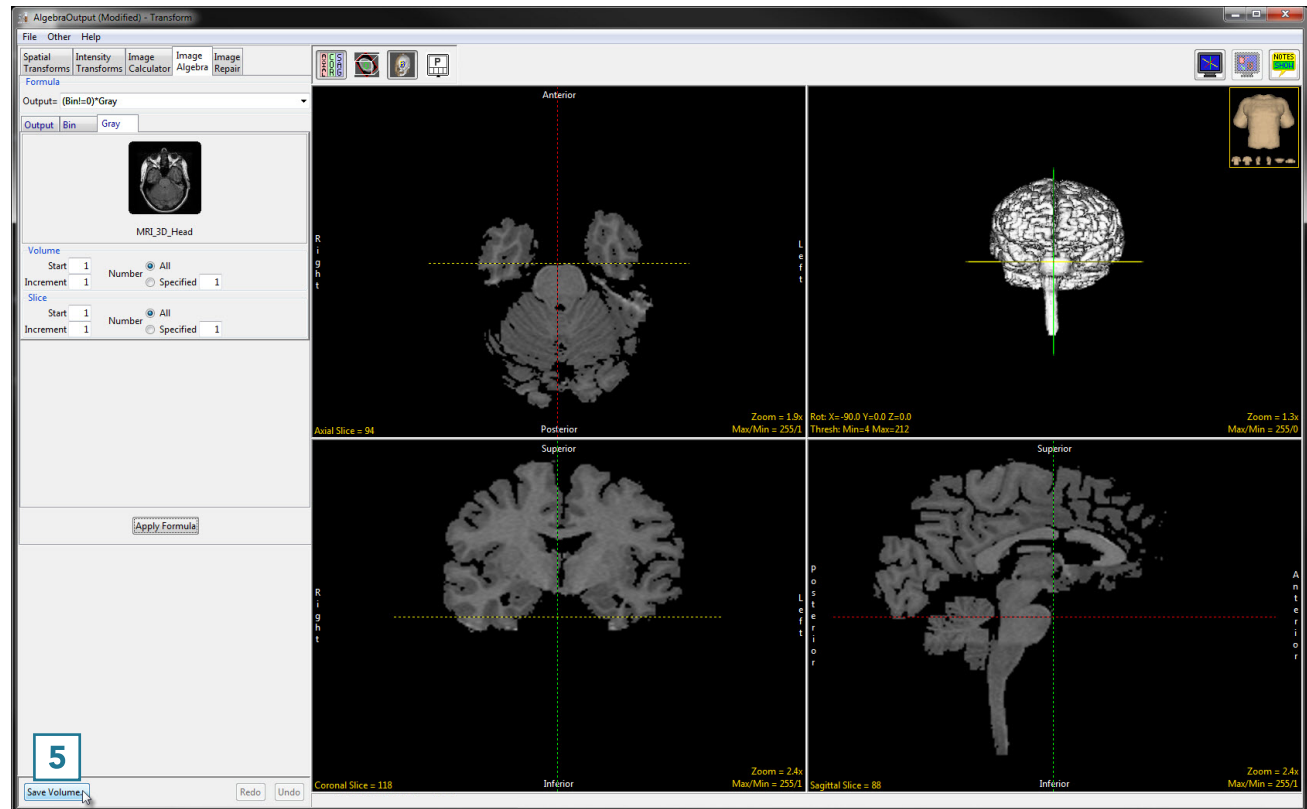


- Once both data sets are loaded into Image Algebra, click the Apply Formula button [4]

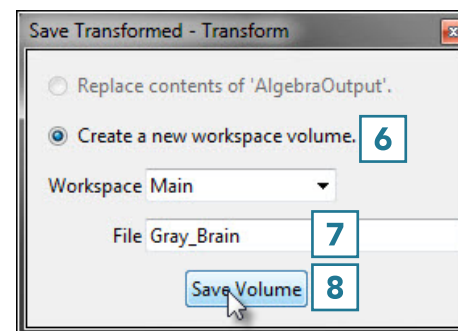


## Applying a Binary Mask to a Grayscale Volume (continued)

- The result is shown to the right.
- Click Save Volume [5] to save the masked data set.



- In the Save Transformed window, choose to create a new workspace volume [6] and rename [7].
- Click Save Volume [8].
- Close Transform.



# Image Repair

The Image Repair tool includes the ability to designate bad slices or subregions that can be repaired by copying voxels from neighboring slices, interpolating across neighboring slices, copying from a related volume or removing bad regions from the volume. Subregion repair includes the ability to blend voxels at the edge of the region. Available options are as follows:

**Bad Slice(s):** This option allows users to specify a range of bad slices or an area of corrupt data.

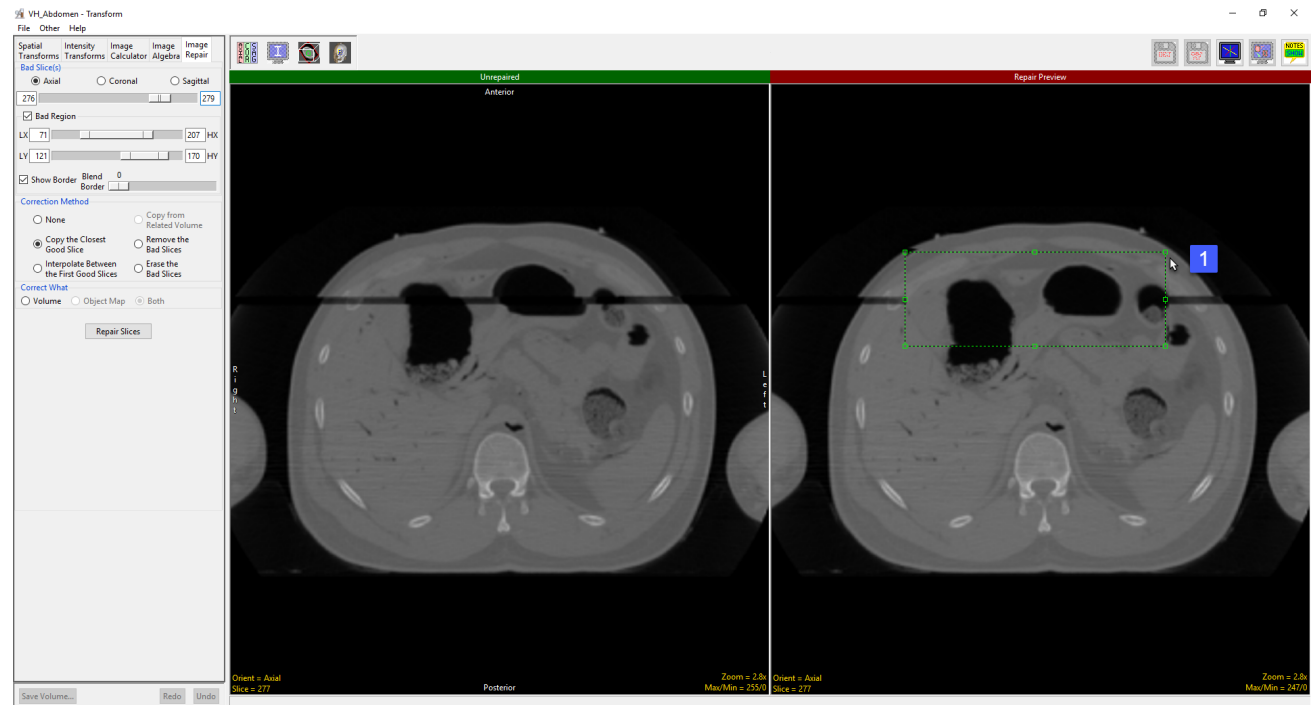
**Axial, Coronal, Sagittal:** Allows a range of slices to be selected in the Axial, Coronal or Sagittal orientations.

**Slider:** The Bad Slices(s) double-ended slider allows users to specify a range of bad slices in the selected orientation.

**Bad Region:** Enables the specification of a region in the image data to repair. The region is defined by the following options:

- LX: Specifies the lowest X coordinate of the bad region.
- HX: Specifies the highest X coordinate of the bad region.
- LY: Specifies the lowest Y coordinate of the bad region.
- HY: Specifies the highest Y coordinate of the bad region.

Alternately, users can use the green selection area shown on the Repair Region image to define the region to repair [1].



## Image Repair Options

### Bad Region (continued)

- **Show Border:** Displays a rectangular box around the region defined by the Bad Region X and Y parameters.
- **Blend Border:** The blend border options allows for the specification of a region around the bad region where the corrected image information is slowly blended with the current image intensities. Move the slider button to adjust the Blend border size. Set this value to zero if no transition area is desired.

**Correction Method:** Allows users to select an appropriate correction methodology. Select from the following options:

- **None:** No correction will occur.
- **Copy the Closest Good Slice:** Copies all the pixel values from the closet non-bad image.
- **Interpolate Between the First Good Slice:** Use Linear interpolation to calculate a replacement slice for each bad slice. The value of each voxel is computed using information for each of the good slices on each side of the bad slices. The percentage of each image uses is calculated based on the distance from the bad slice to each good slice.
- **Copy from Related Volume:** Only available if a related volume is loaded. This option copies all pixel values from the related volume. Commonly used with a mirrored and registered copy of the input volume to symmetric features in regions.
- **Remove the Bad slices:** The slices are removed and the slices after the last bad slice are shifted to the area removed. This option leave blanks in the last few images for the selected orientation.
- **Erase the Bad Slices:** The selected range of bad slices are just set to the minimum data type value.

**Correct What:** The correct what options allows user to correct the original image data (Volume), a loaded object map (Object Map), or both the original image data and object map (Both).

**Repair Slices:** Applies the selected correction method to range of the bad slices, or regions within those slices.

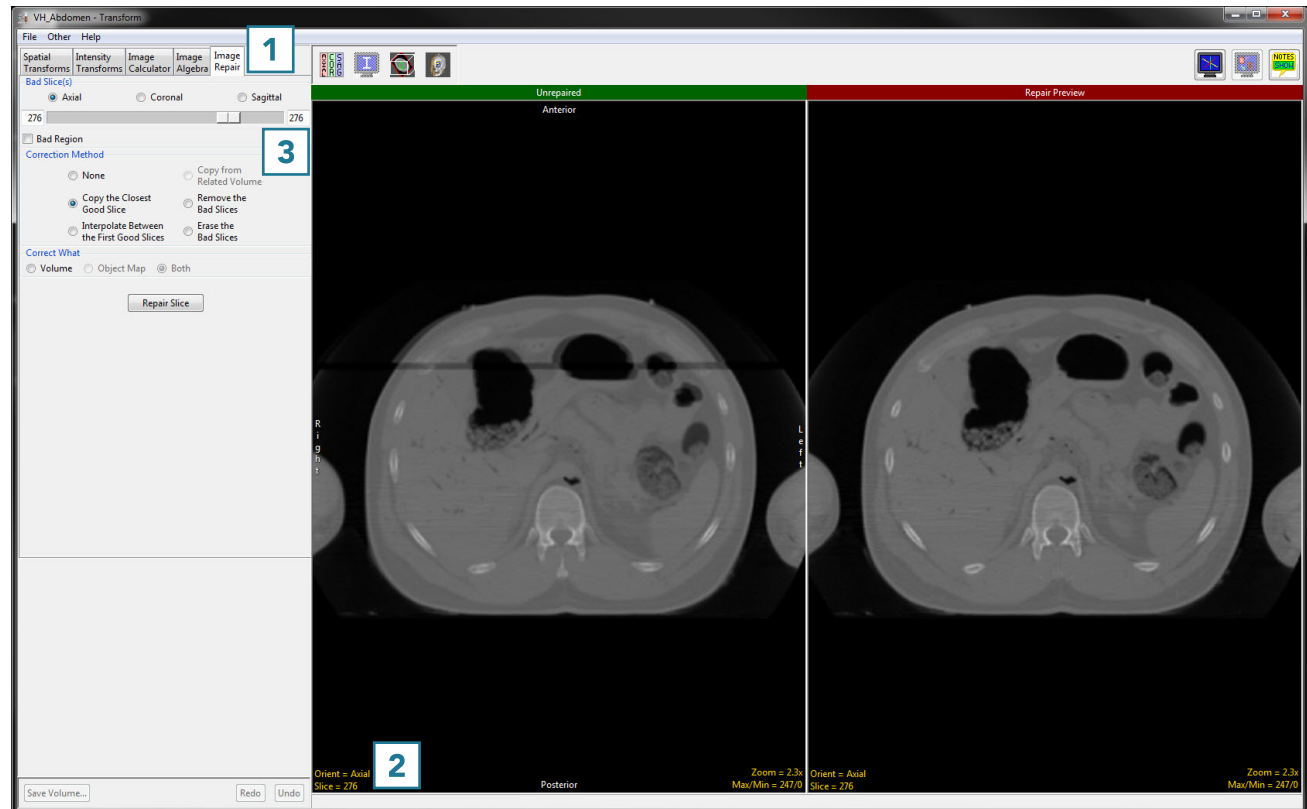
## Repairing an Image

Here we will repair an image that has a series of corrupt slices.

### Repairing an Image

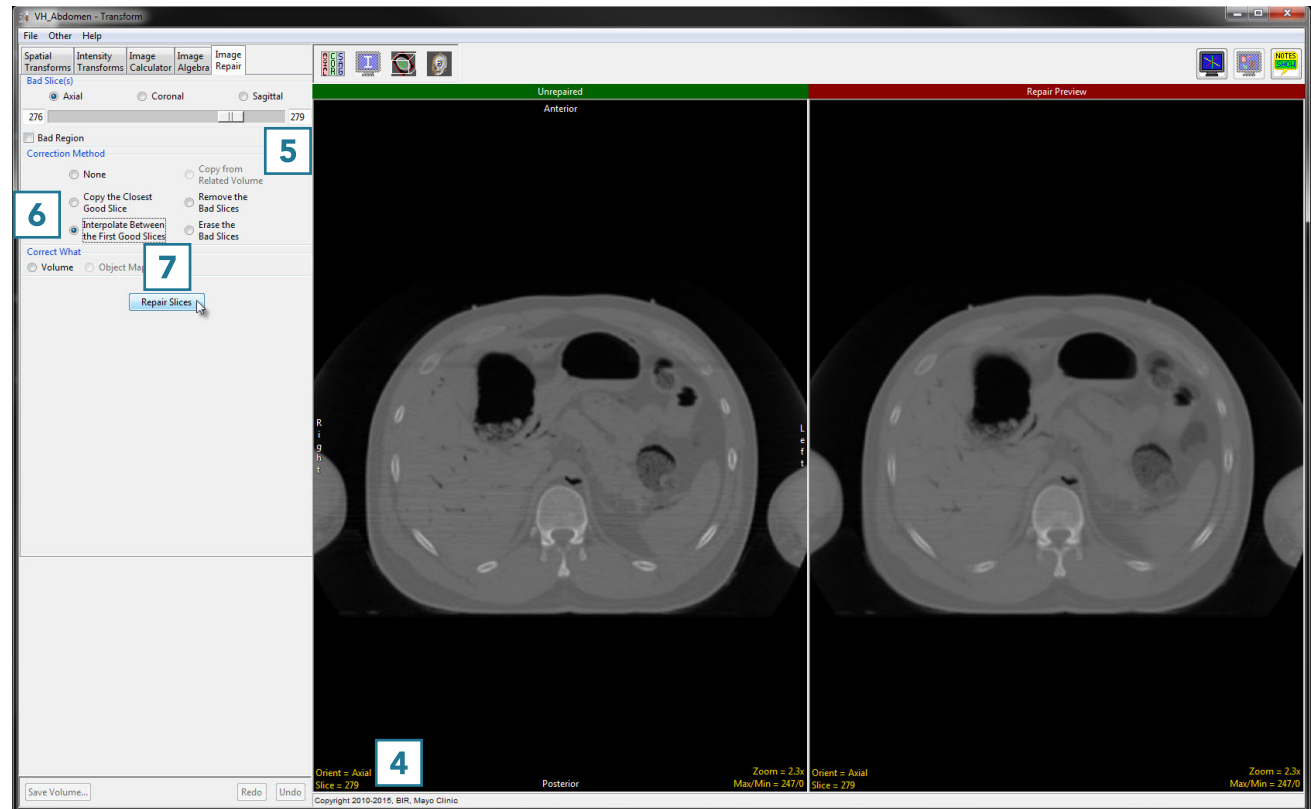
To follow along, download the VH\_Abdomen data set from [analyzedirect.com/data](http://analyzedirect.com/data) and load into Analyze using Input/Output.

- Open Transform and navigate to Image Repair [1].
- Navigate to the first corrupt slice in the data set, which for this example is slice 276 [2].
- Move the lower limit of the bad slices slider bar to 276 [3].



## Repairing an Image (continued)

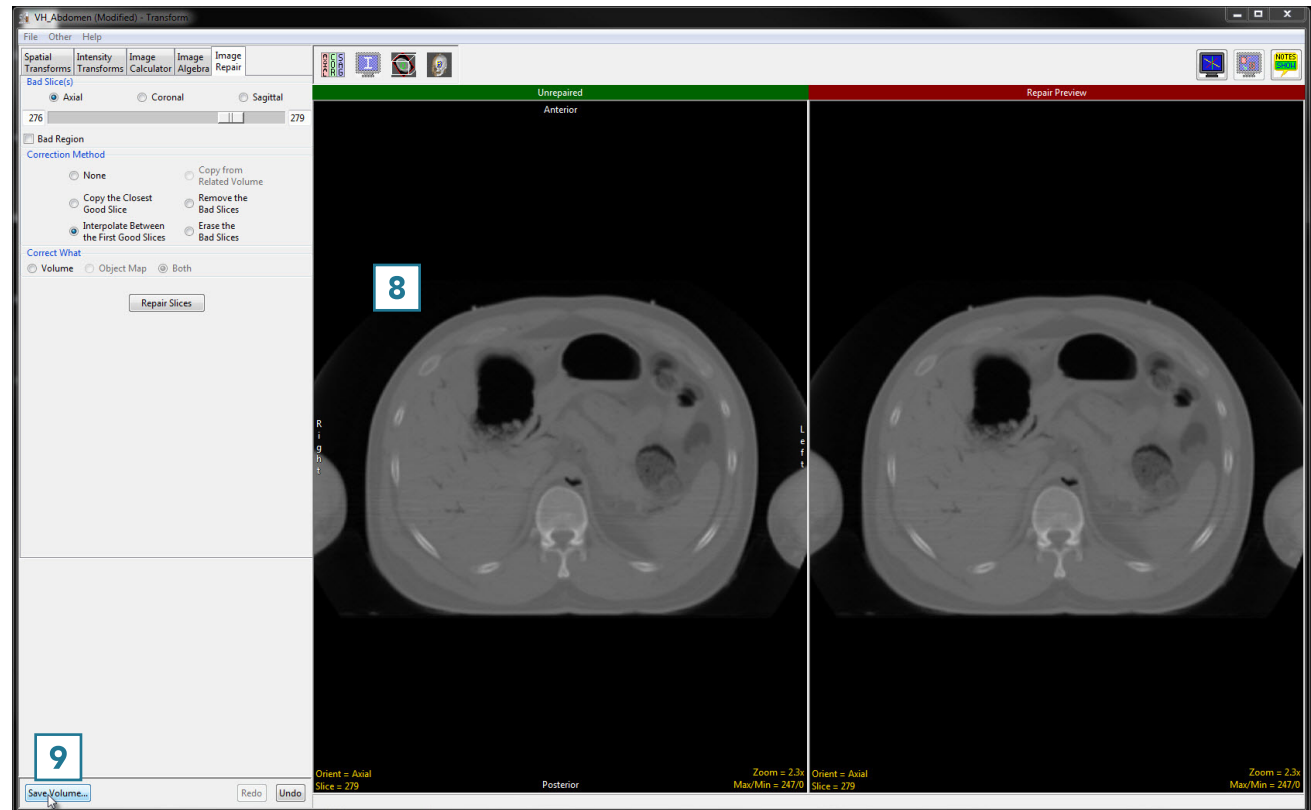
- Navigate to the last corrupt slice in the data set, which for this example is slice 279 [4].
- Move the upper limit of the bad slices slider bar to 279 [5].
- Set the correction method to Interpolate Between the First Good Slices [6].
- Click Repair Slices [7] to apply the correction.



## Repairing an Image (continued)

Note that the repaired version now appears on the left side of the window [8]

- Click Save Volume [9] to save the corrected data set.



- In the Save Transformed window, choose to create a new workspace volume [10] and rename [11]
- Click Save Volume [12].
- Close Transform.

