Transform

Introduction

There are several types of transformations that can be applied to data: spatial transformationss such as cropping, resizing or flipping; intensity transformations such as thresholding, intensity scaling and inversion; custom transformations using mathematical operators with image calculator/image algebra and image repair.
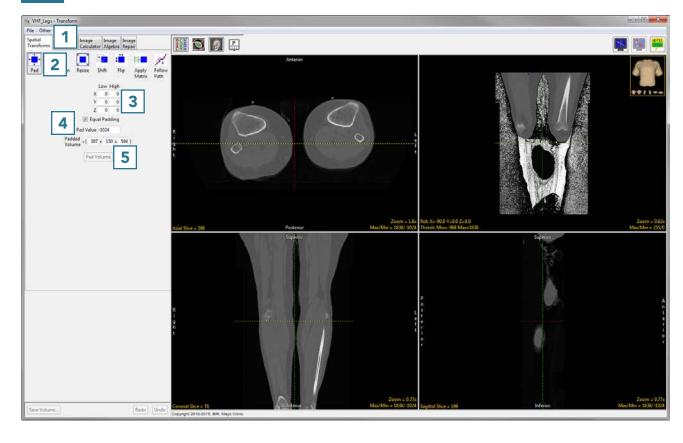
Spatial Transforms

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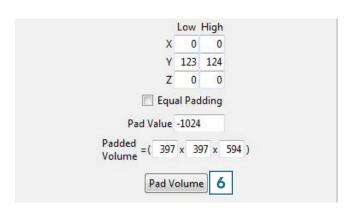
Pad

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.

- Select the data set to crop 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.

Download the VHF_Legs data set to follow along http://analyzedirect.com/data/

- Once the dimensions have been changed from the original dimensions, the Pad Volume button will update.
- Click Pad Volume to apply the changes. **6**

<table>
<tr><td></td><td>Low</td><td>High</td></tr>
<tr><td>X</td><td>0</td><td>0</td></tr>
<tr><td>Y</td><td>123</td><td>124</td></tr>
<tr><td>Z</td><td>0</td><td>0</td></tr>
</table>

☐ Equal Padding

Pad Value -1024

Padded Volume = (397 x 397 x 594)

Pad Volume **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 7 and click Save Volume. 8
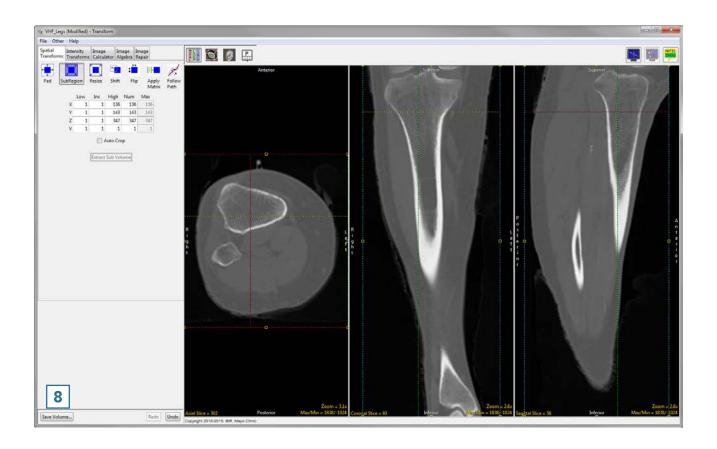- Close Transform.

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.

Download the VHF_Legs data set to follow along
http://analyzedirect.com/data/

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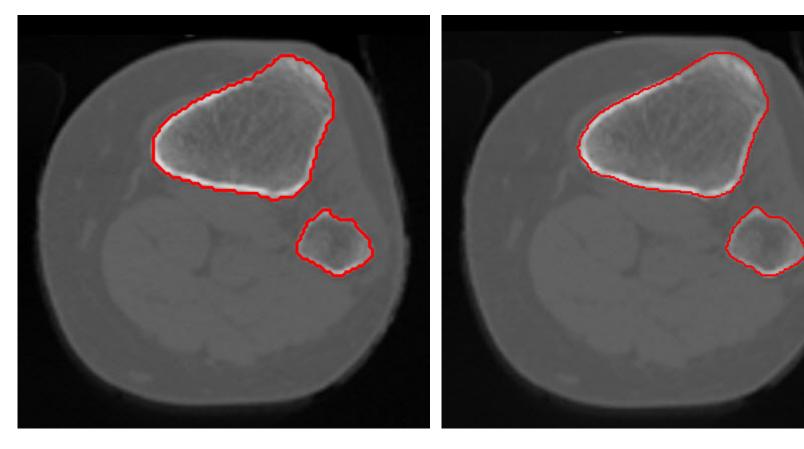
- Click Save Volume **8** to save the cropped data set.

- 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

- 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 Table 3.4 or 6.1 for different interpolation types.

- Click Resize Volume **6** to resample the data set.

Download the VHF_Legs data set to follow along http://analyzedirect.com/data/

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.

Table 6.1: 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
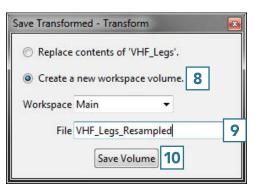
*The Nearest Neighbor and Linear interpolation types can be specified as ID or OD.

**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.

• Click Save Volume **7** to save the resampled data set.

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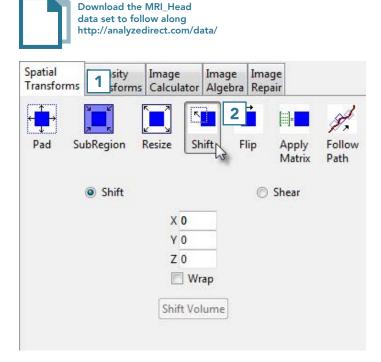 9 then click Save Volume. 10
- Close Transform.

Save Transformed - Transform

○ Replace contents of 'VHF_Legs'.

● Create a new workspace volume. 8

Workspace Main

File VHF_Legs_Resampled 9

Save Volume 10

Shift

The Shift tool can be used to shift data horizontally or vertically. This may be necessary to correct wraparound artifacts.
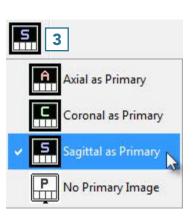
Download the MRI_Head data set to follow along
http://analyzedirect.com/data/

1. Correcting Wraparound Using the Shift Tool

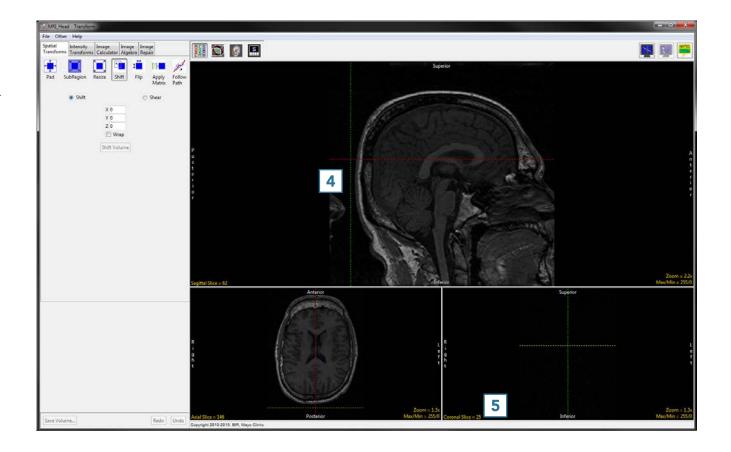- Select the data set to shift and open Transform. Navigate to Spatial Transforms 1 and select the Shift tool. 2

- 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**

- 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**
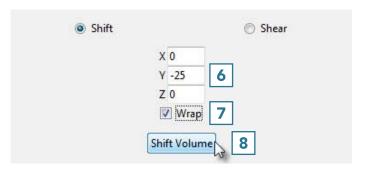
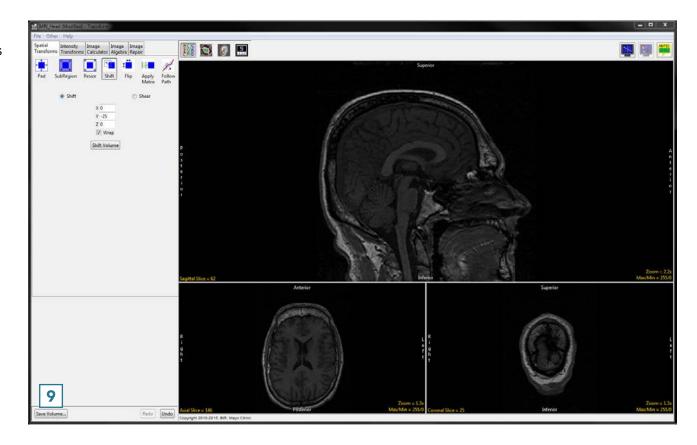Refer to Table 6.2 to determine the correct sign and direction of the desired shift.

Table 6.2: Shift Parameters

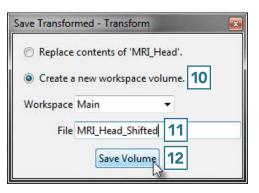| Parameter	Axial		Coronal		Sagittal	
	+	-	+	-	+	-
X	right	left	right	left		
Y	up	down			right	left
Z			up	down	up	down

- 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

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.
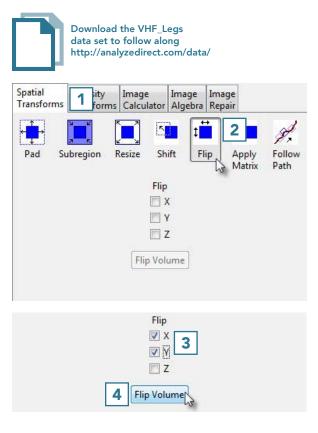
Table 6.3: Flip Parameters

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.

2. Flipping Data

- 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.

Download the VHF_Legs data set to follow along http://analyzedirect.com/data/

• The data set before and after the X-Y flip is shown below. 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
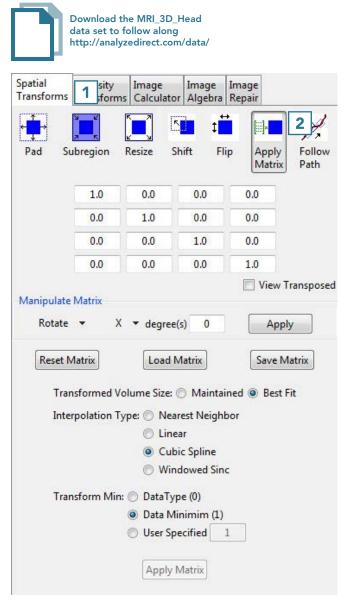- Rename 7 and click Save Volume. 8
- Close Transform.

Save Transformed - Transform

○ Replace contents of 'VHF_Legs'.

⦿ Create a new workspace volume 6

Workspace Main

File VHF_Legs_Flipped 7

Save Volume 8

Apply Matrix

The Apply Matrix tool 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 4 X 4 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.
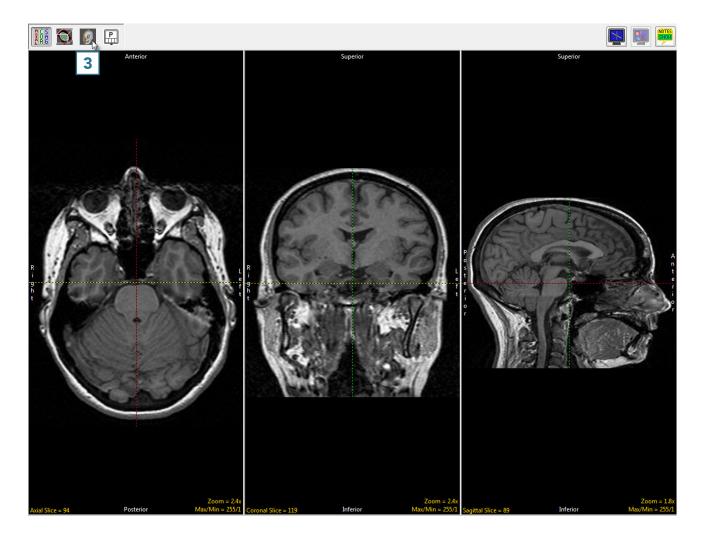
3. AC-PC Alignment of Brain Data

- Select the data set to align along the AC-PC axis and open Transform.
- Navigate to Spatial Transforms. **1**
- Select the Apply Matrix tool. **2**

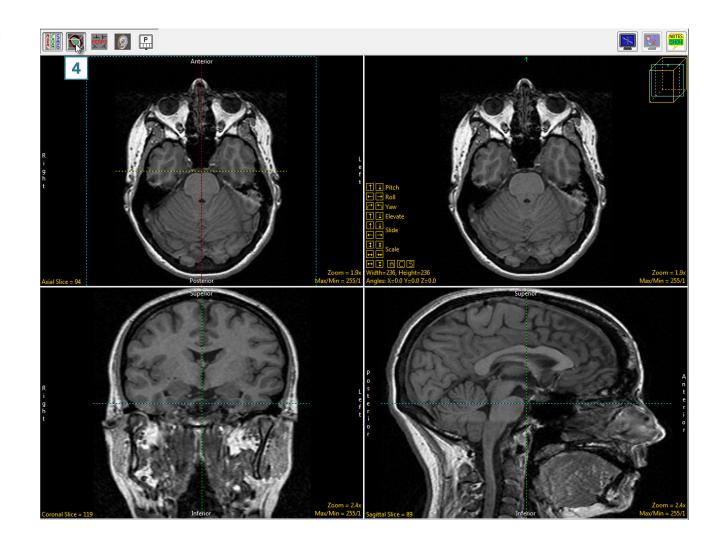Download the MRI_3D_Head data set to follow along http://analyzedirect.com/data/

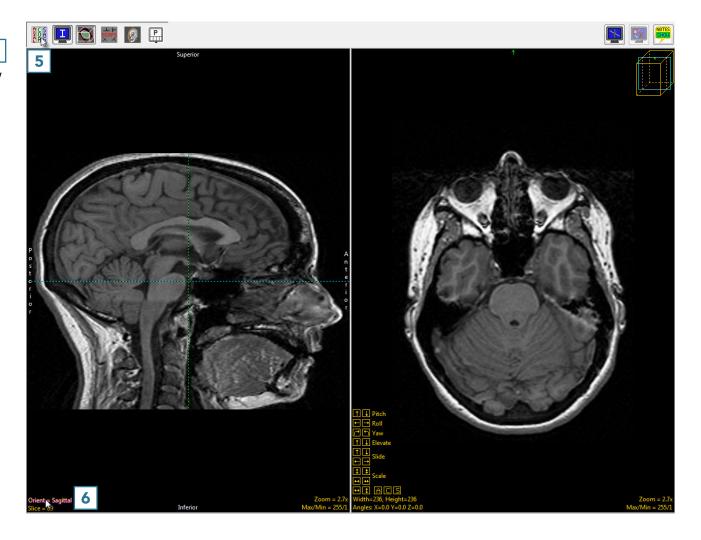The optimal display settings for AC-PC alignment or any other manipulation of an oblique plane are as follows:

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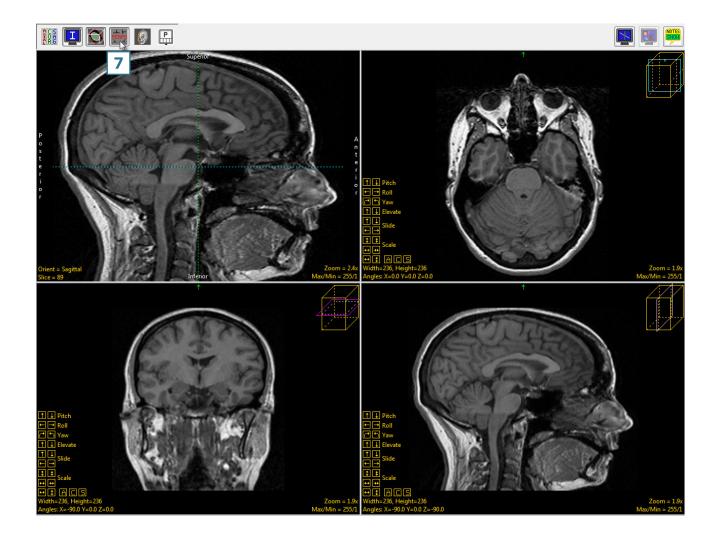
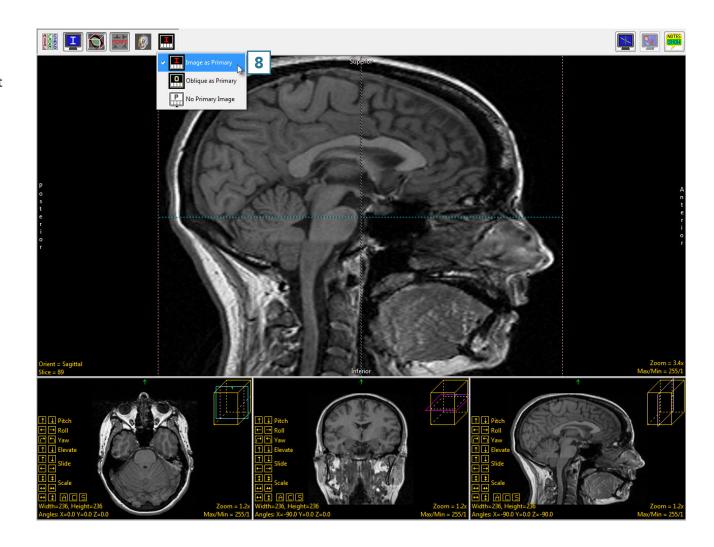• Switch on the oblique. [4] Now, the oblique and the three orthogonal views are shown.

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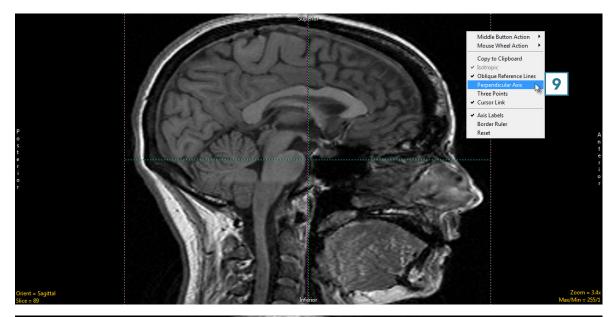- Now the sagittal orientation and the oblique image are shown.

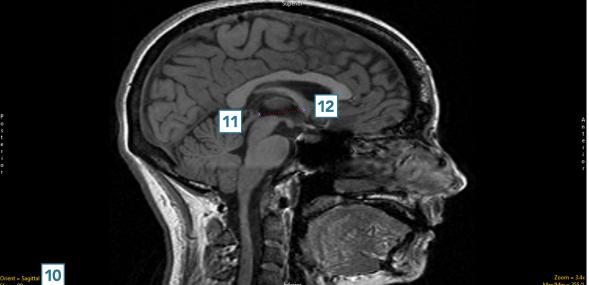- Switch on the perpendicular images. **7**

- 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.
- 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
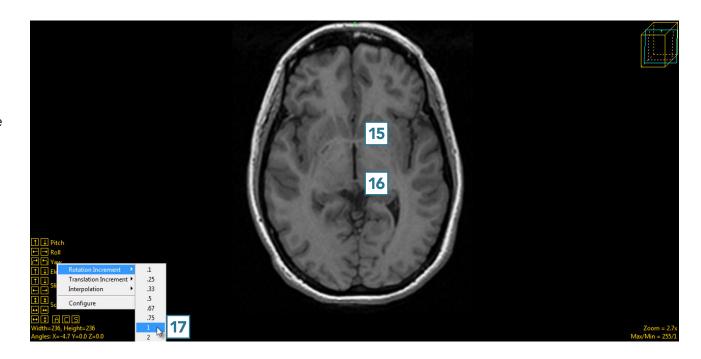- Drag the right endpoint of the perpendicular axis to the anterior commissure. 12

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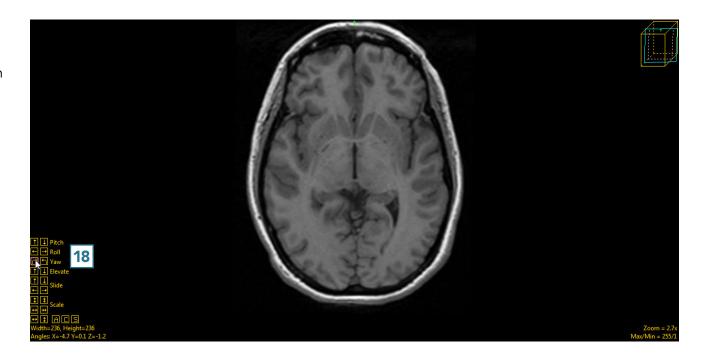
- Now the main oblique image (the leftmost of the three) is an AC-PC aligned axial image. **14**
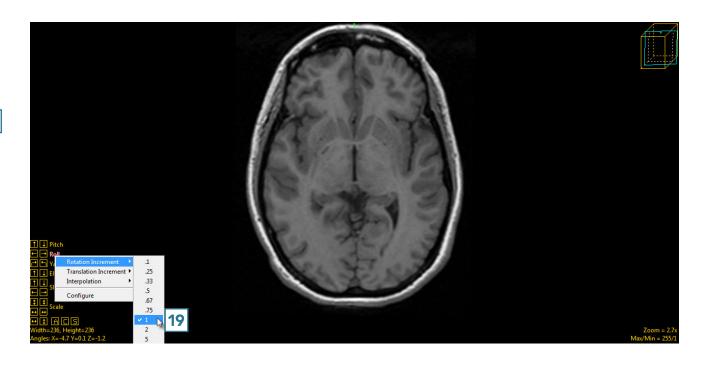- Double-click this image to make it the primary image.

- 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]
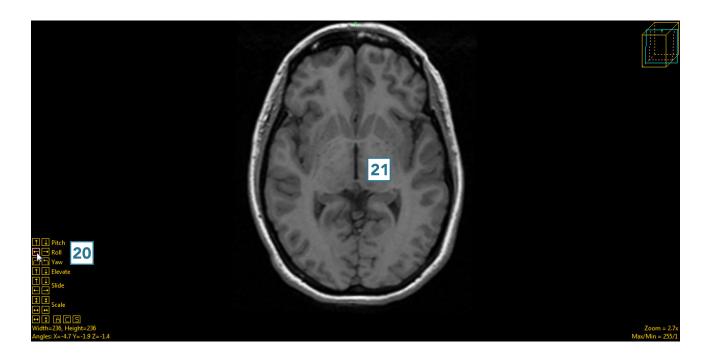
- Use the left and right Yaw buttons to align the data set vertically. 18 The increment can be made even smaller to make smaller adjustments as needed.
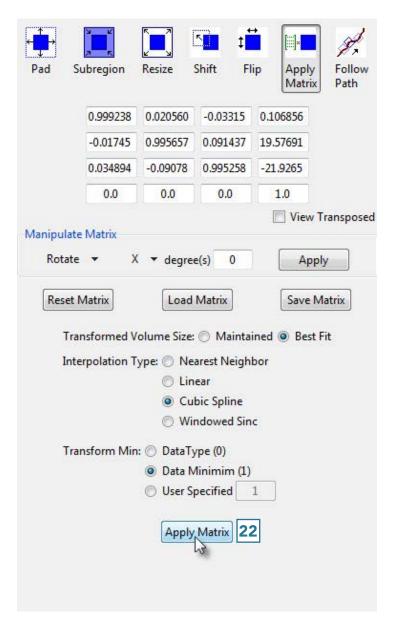
• The last adjustment to be made to the oblique plane will be done using the Roll function. Right-click on Roll and change the Rotation Increment to 1. **19**

- Click on the left and right roll buttons [20] to adjust the data set until the anatomical structures appear symmetrical. [21]
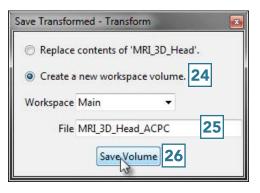
- Click Apply Matrix 22 to apply the transformation.

• 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.
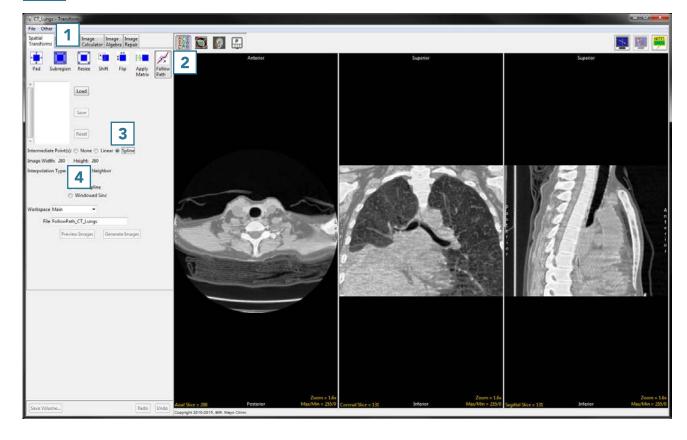
Follow Path

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.

4. Reslicing Data along the Trachea

- 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.
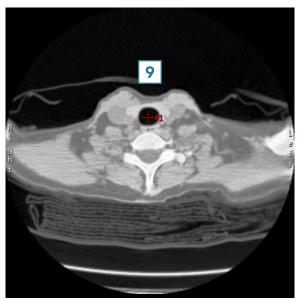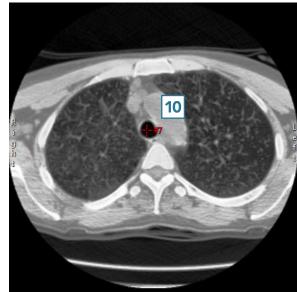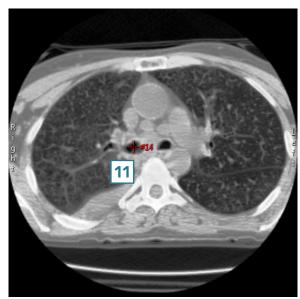
Download the CT_Lungs data set to follow along
http://analyzedirect.com/data/

- The interpolation type [5] can be set to nearest neighbor, bilinear, cubic spline or windowed sinc. For more information on interpolation types, see Table 6.1.

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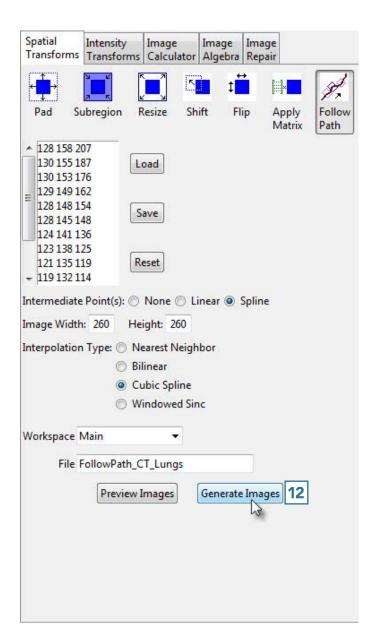
- Click in the trachea to set the first point. **9**
- Scroll through the slices and continue to set points along the path **10** until reaching the last point of the desired path. **11**

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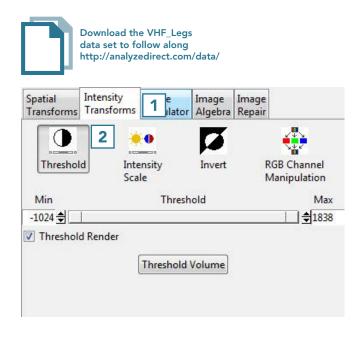- Close Transform.

Intensity Transforms

The Intensity Transforms available in AnalyzePro include thresholding, intensity scaling, inversion and RGB channel manipulation. Many of the functions available in this section are also available via Input/Output > Process > Intensities.

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.

Download the VHF_Legs data set to follow along
http://analyzedirect.com/data/

5. Creating a Binary Data Set with Thresholding

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

- 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.

- 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 9 and click Save Volume. 10
- Close Transform.

Save Transformed - Transform

○ Replace contents of 'VHF_Legs'.

◉ Create a new workspace volume. 8
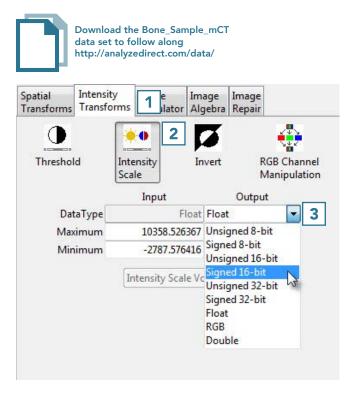
Workspace Main

File VHF_Legs_Binary 9

Save Volume 10

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.
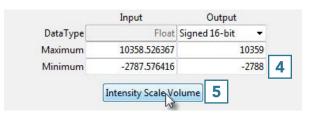
6. Modifying Image Data Type

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.

- 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**

Download the Bone_Sample_mCT data set to follow along
http://analyzedirect.com/data/

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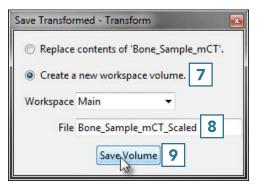will be set to the default values for
the signed 16-bit data type.

- 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.

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

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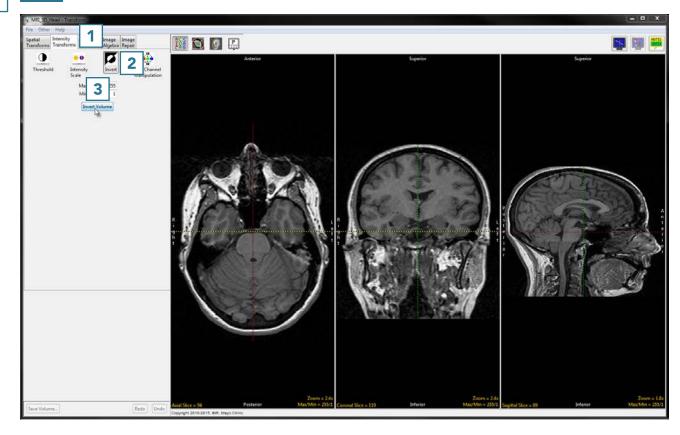- Rename the file. **8**
- Click Save Volume. **9**
- Close Transform.

Invert

For certain segmentation and visualization applications, it is beneficial to view an inverted copy of the image data alongside the original grayscale data.

7. Inverting Data

- 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.

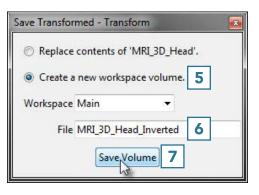Download the MRI_3D_Head data set to follow along
http://analyzedirect.com/data/

• 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.

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:

Table 6.4: 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
Extract Red Channel	Specifies that only the 8-bit red channel is used
Extract Green Channel	Specifies that only the 8-bit green channel is used
Extract Blue Channel	Specifies that only the 8-bit blue channel is used

Data can also be converted to a 24-bit color image using the following options.

Table 6.5: Conversions to 24-bit Options

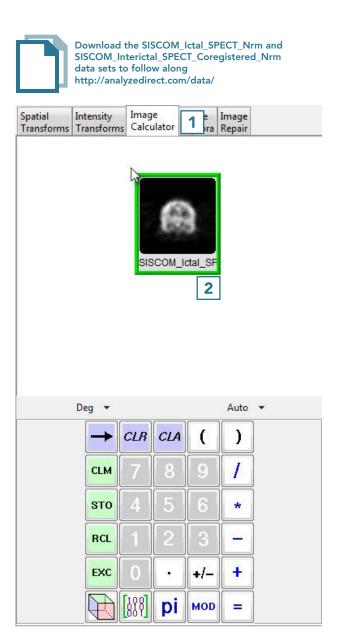| Option	Description
Data w/Colormap	Converts a data set with a colormap loaded into a 24-bit color image
Object Colored	Uses a data set and an object map to make a 24-bit data set where all the voxels have been colored using colors and definitions in the object map
Combine Channel(s)	Combines the red, green and blue channels into a 24-bit color image

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.
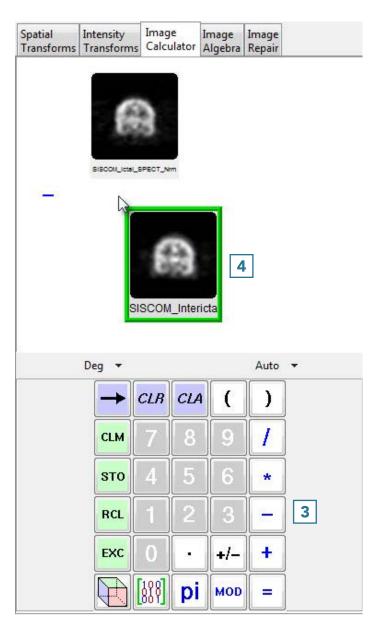
8. Creating a Difference Map

This exercise will show how to create a difference map showing the areas of higher blood flow to the brain during an epileptic seizure. Interictally (in a non-seizure state), many epilepsy patients exhibit hypoperfusion in the region of the seizure focus. Ictally (during seizure), radiotracers can be injected to produce an image of cerebral perfusion patterns. The difference map between the ictal and interictal SPECT data sets can be used to determine the region of increased activation during seizure.
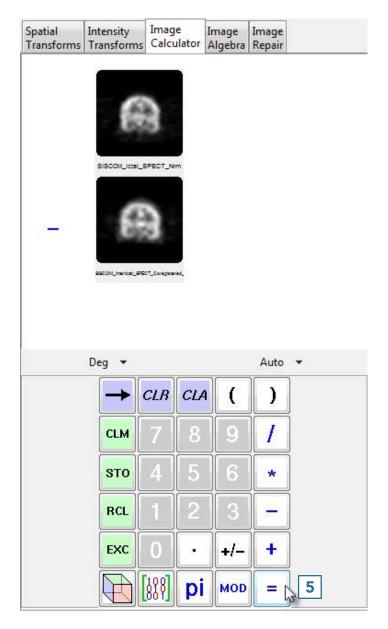
- The SPECT data inputs for this exercise have already been registered and normalized so that they can be compared.
- Open Transform and navigate to Image Calculator. [1]
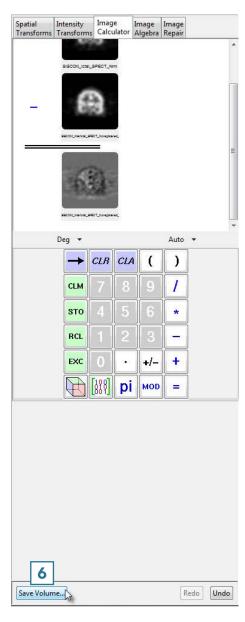- Drag and drop the ictal data set into the calculator window. [2]

Download the SISCOM_Ictal_SPECT_Nrm and SISCOM_Interictal_SPECT_Coregistered_Nrm data sets to follow along
http://analyzedirect.com/data/

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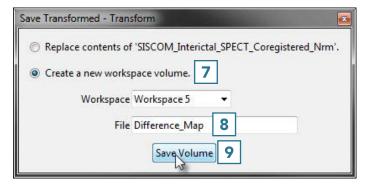- Drag and drop the interictal data set into the calculator window. **4**

• Press the equals key 5 to complete the subtraction.

• 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.

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.
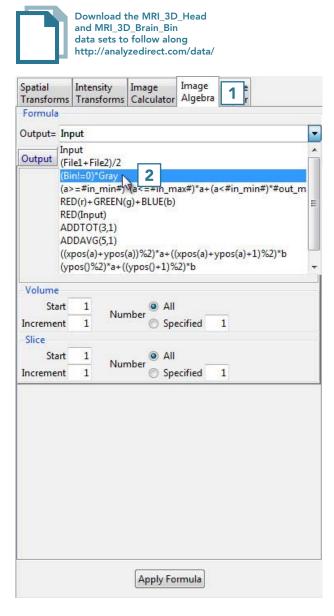
Table 6.6: Preloaded Image Algebra Formulas

| 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)
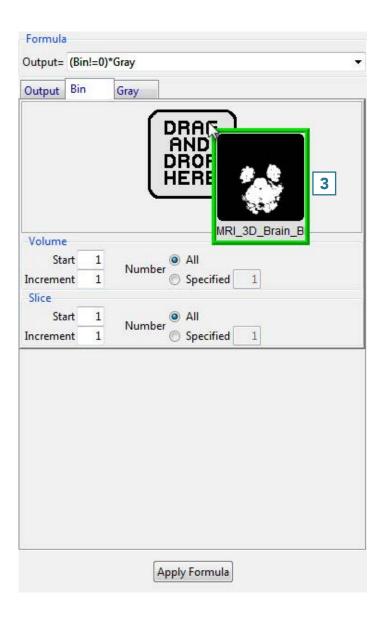
9. Applying a Binary Mask to a Grayscale Volume

This exercise demonstrates how to multiply 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.
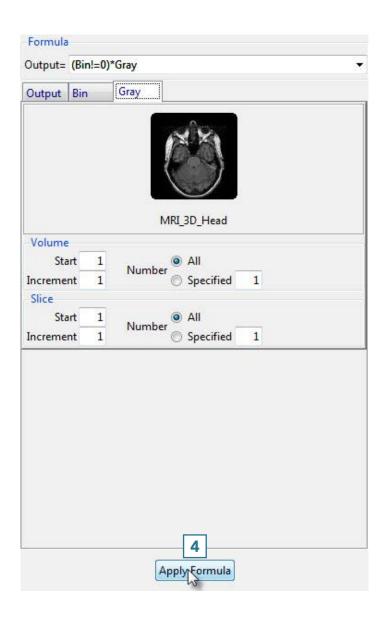
Download the MRI_3D_Head and MRI_3D_Brain_Bin data sets to follow along
http://analyzedirect.com/data/

- Open Transform and navigate to Image Algebra. **1**
- From the formula drop-down, select the third option down: (Bin!=0)*Gray. **2**
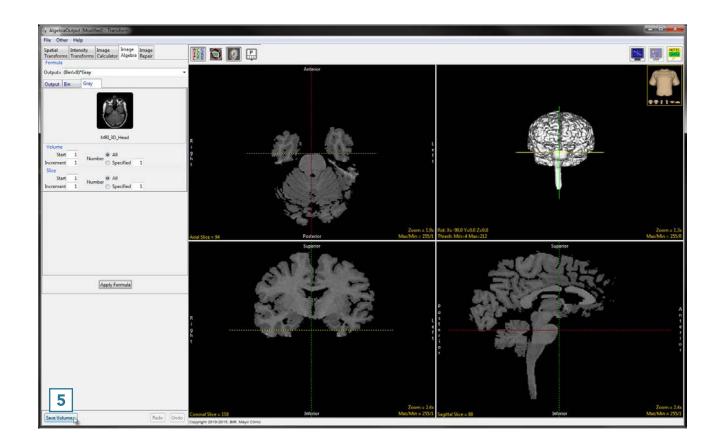
- The input variables will appear as tabs labeled with the variable names.
- Drag and drop the binary data set into the designated space on the Bin tab. 3
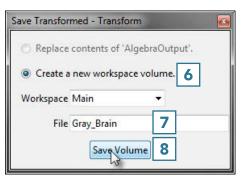- Do the same with the grayscale data set on the Gray tab.

• Once both data sets are loaded into Image Algebra, click the Apply Formula button. **4**

Formula

Output= (Bin!=0)*Gray

Output | Bin | Gray

MRI_3D_Head

Volume

Start 1   ◉ All
                Number
Increment 1   ○ Specified 1

Slice

Start 1   ◉ All
                Number
Increment 1   ○ Specified 1

4

Apply Formula

• 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]
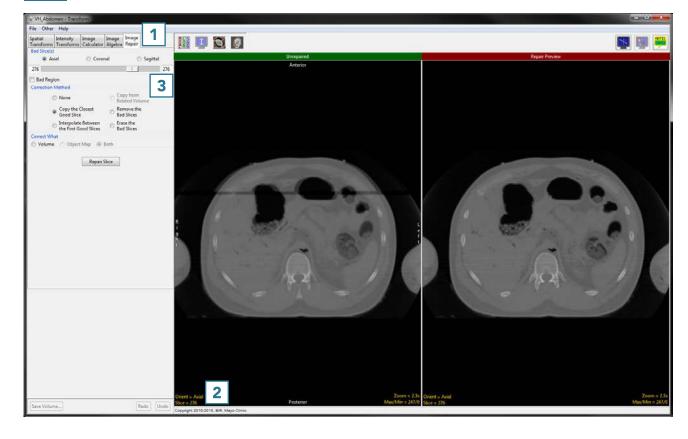- Click Save Volume. [8]
- Close Transform.

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.
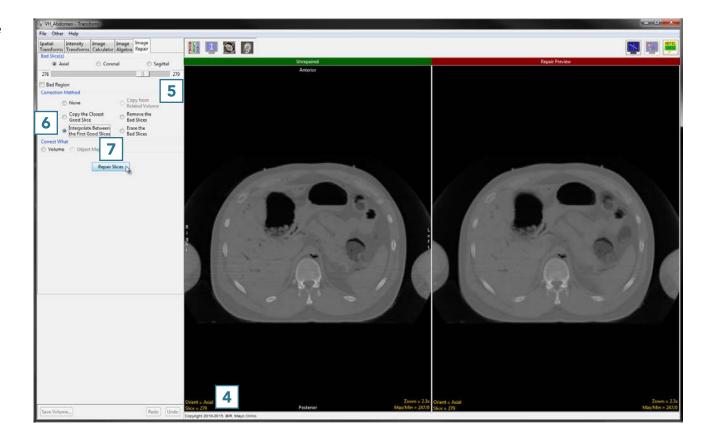
10. Repairing an Image

- 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**

Download the VH_Abdomen data set to follow along
http://analyzedirect.com/data/

- 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.

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.