4 Understanding Image Basics

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This chapter also explains the dimensionality and coordinate system used by MIPAV, the data types MIPAV supports, the header offset information, endianness, and how to view and edit image attributes.It also provides a basic information about image file formats supported by MIPAV. More information about graphic file formats and the formats that MIPAV supports can be found in Appendix C: "Supported formats" .

Supported graphic formats overview

MIPAV supports three categories of graphic file formats: vector (i.e., volume of interest, or VOI), bitmap (i.e., 2D to 5D grayscale or RGB images), and 3D images.

Vector file formats are usually used to store line-based elements. These elements can be geometric shapes, such as polygons, curves, or splines. MIPAV can read and generate several vector-formatted file types including the MIPAV lookup table (LUT), MIPAV MTX, MIPAV Graphics Plot (PLT), and MIPAV VOI. See also Appendix C: “Supported formats” on page 591.

Bitmap file formats are usually used to store real-world graphics data e.g., photographs or medical images such as CT scans. The data portion of bitmap files contains numerical data that indicates the color of each pixel or voxel in the image. MIPAV can read and generate a number of bitmap formatted file types, such as Adobe Photoshop (PSD), Graphics Interchange File (GIF), Sun Raster (RS), Tagged Image File Format (TIFF), and Truevision Graphics Adapter (TGA).

MIPAV uses 3D graphic formatted files to store descriptions of the color and shape of 3D models of real-world and imaginary objects.

To support the wide range of image-processing needs of the NIH intramural research community, MIPAV reads and writes the image file types indicated in Table 22, refer to Appendix C: “Supported formats” on page 591.

Understanding the MIPAV dimensionality and coordinate system

Internally, MIPAV is designed to store images of any dimensionality and thus is *n* dimensional. Figure 58 is a model of an example 3D-image where each position within the grid represents a *voxel*.

voxel—The smallest distinguishable cube-shaped part of a 3D-image.

The voxel in the upper left-most position is considered the origin of the

dataset. (A volumetric dataset is a set of cross-sectional images). Ideally, each voxel would be isotropic (i.e., cubic), but clinical datasets are often acquired in such a manner that the resolution in the *x* and *y* dimensions is greater than the resolution in the *z* dimension, thus producing rectangular voxels (elongated in the *z* direction). This voxel anisotropy is taken into account in the execution of the algorithms found in MIPAV.

Because MIPAV's image storage buffer is *n*-dimensional, it can store 2D, 3D, and 4D+ medical images. CT and MRI are examples of 3D medical images where the three dimensions (*x*, *y*, and *z*) are spatial dimensions. Other 3D datasets include fluoroscopy volumes, where the first two dimensions are spatial and the third dimension is time.

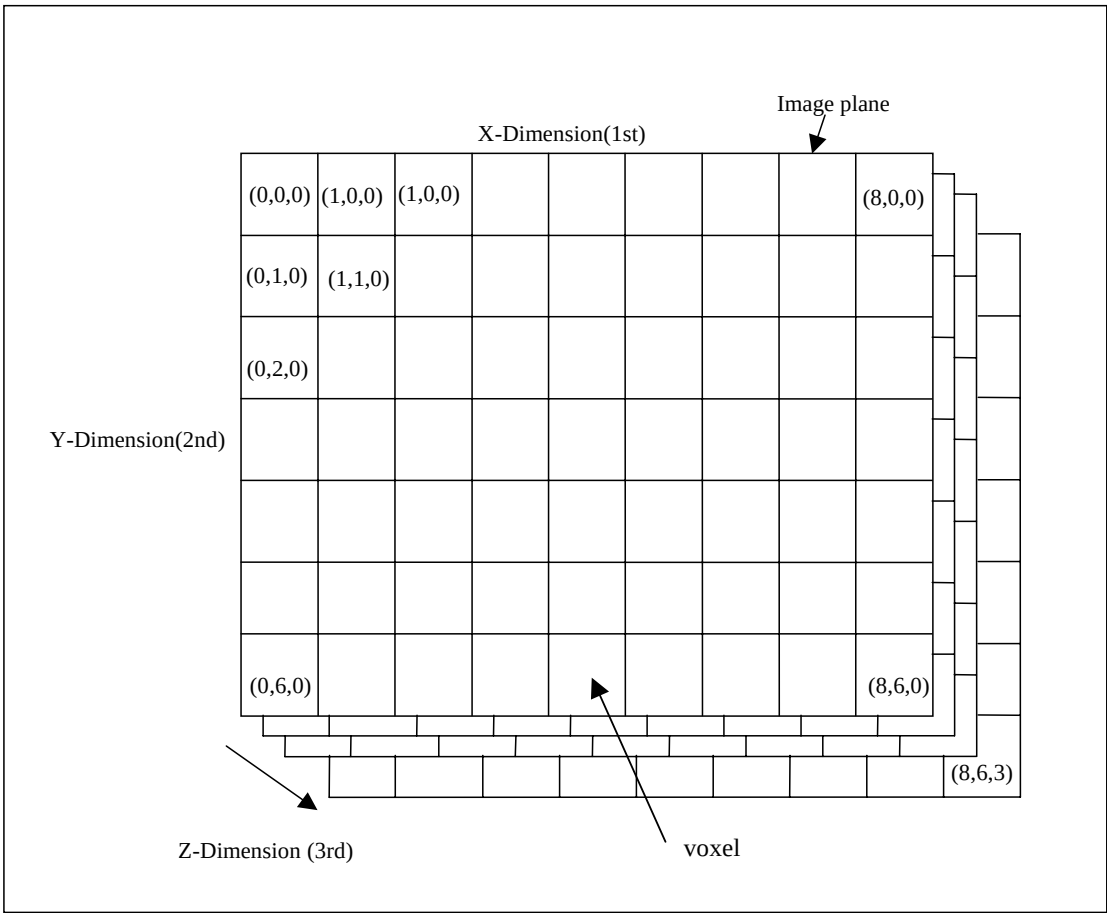


Figure 58. Example of 3D image (origin at top left)

Data types

A *data type* is the classification of a particular type of information. For example, a floating point data type indicates a number with a decimal point. Data read from image files are stored in MIPAV's data structures. MIPAV supports all the basic data types shown in Table 2and may in the future support more composite data types including color and complex numbers. The image data read from the file is stored in a data buffer of the same basic data type, preventing the reduction of image information that results from conversion into a fixed data type.

Table 2. Data types supported by MIPAV

Data type	Description
Boolean	1 bit per pixel/voxel (1 on, 0 off)
Signed byte	1 byte per pixel/voxel (-128, 127)
Unsigned byte	1 byte per pixel/voxel (0, 255)
Signed short	2 bytes per pixel/voxel (-32768, 32767)
Unsigned short	2 bytes per pixel/voxel (0, 65535)
Integer	4 bytes per pixel/voxel (-2^{31}, $2^{31}-1$)
Long	8 bytes per pixel/voxel (-9.22E18, 9.22E18)
Float	4 bytes per pixel/voxel (-3.4E38, 3.4E38)
Double	8 bytes per pixel/voxel (-1.8E308, 1.8E308)
Color 32	3 bytes per pixel/voxel, plus 1 byte; 8 bits per color channel (alpha, red, green, and blue)

Headers

If you attempt to open a raw image, you may need to supply MIPAV with the *header offset*. The header offset indicates the size of the space reserved at the beginning of the file where specific types of information is kept. This space, which is called the header, precedes the image data. If you know the length of the header, enter it in the header offset text box. When MIPAV accesses the file, it skips the header offset and begins to read the image data.

Note: Not all image file formats have a header.

Endianness

Endianness refers to the byte ordering of the data. Some computers order the data with the least significant byte (LSB) first followed by the most significant byte (MSB). This byte order is referred as “little endian” or Intel byte ordering. machines that use little-endian byte ordering are VAXes, Intel x86, and Pentium. The reverse is MSB then LSB, which is referred as “big endian” or Motorola byte ordering. Machines that use big-endian byte ordering are IBM System 3D, RISC, and a Motorola 680x0. MIPAV is biendian; that is, it supports both big- and little-endian byte-ordering formats.

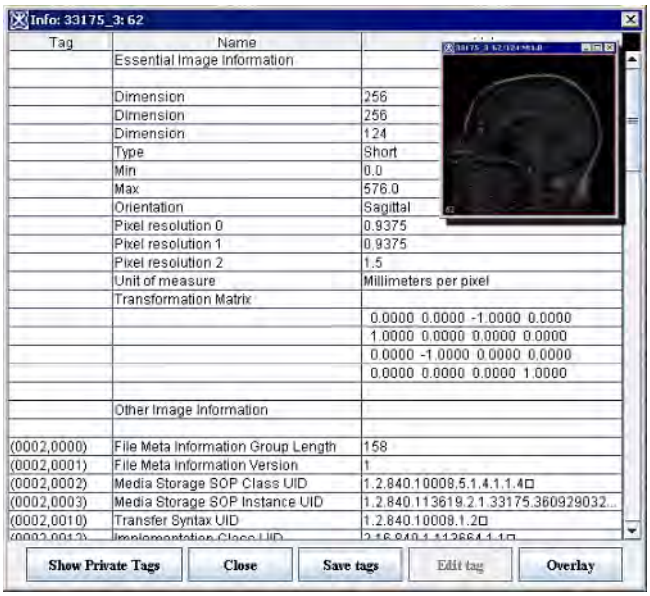
Viewing and editing image attributes

Information about the image appears in the Image Information dialog box and in the Image Attributes dialog box.

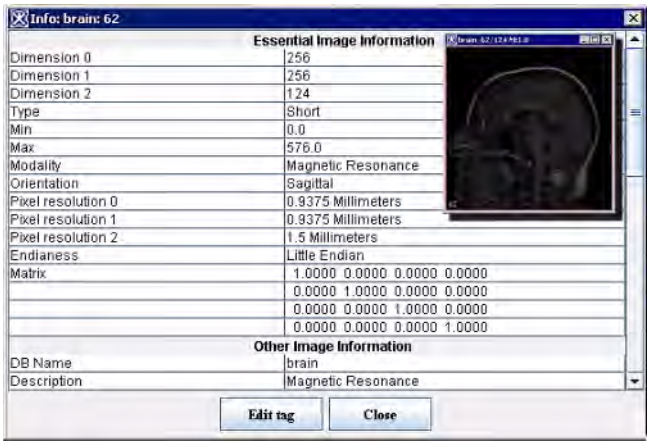
The Image Attributes window displays the name of the image file and information about the resolution of the image. The About Image window displays more detailed information about the image, such as the orientation of the image or the number of bits per pixel or voxel.

Viewing image attributes

To view the attributes of an image, select Image > Attributes > View Header in the MIPAV window. For DICOM datasets, the Image Information dialog box similar to the one shown in Figure 59-a appears. For non-DICOM datasets, an Image Information dialog box similar to the one in Figure 59-b appears.



(a) the Info dialog box for DICOM images



(b) the Info dialog box for non-DICOM images

Figure 59. The Info dialog box for DICOM (a) and non-DICOM (b) images

Editing image attributes

You can edit some of the image attributes for both DICOM datasets and non-DICOM datasets in the Image Attributes dialog box (Figure 60). The Image Attributes dialog box includes five tabbed pages, which are the following:

- **General page** displays the name of the image (without its extension, or suffix) and lists the image modality
- **Resolutions page** indicates the unit of measure for each dimension
- **Orientations/Origin page** lists the image orientations
- **Transform Matrix** displays and lists the values for the transform matrix
- **Talairach** displays Talairach transform

By default, the General page always appears first when the Image Attributes dialog box opens.

IMAGE ATTRIBUTES DIALOG BOX

Apply	applies the changes to the current image, but doesn't close the dialog box.
OK	applies the changes to the current image and closes the dialog box.
Close	closes the dialog box without applying the changes to the image.
Help	opens the on-line help.

General tab

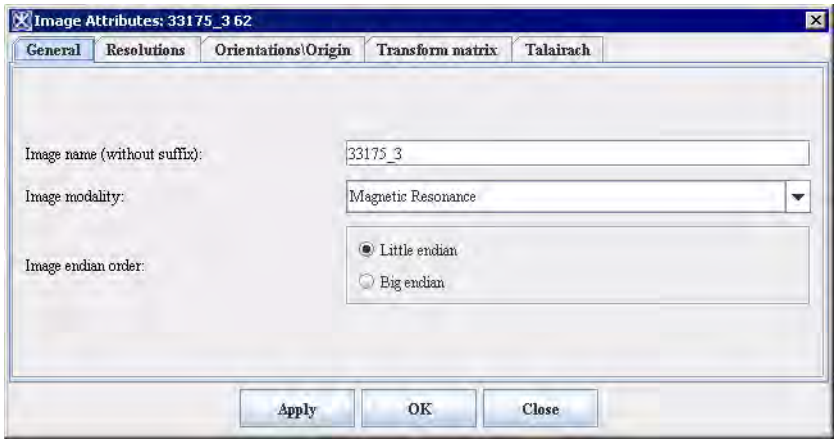
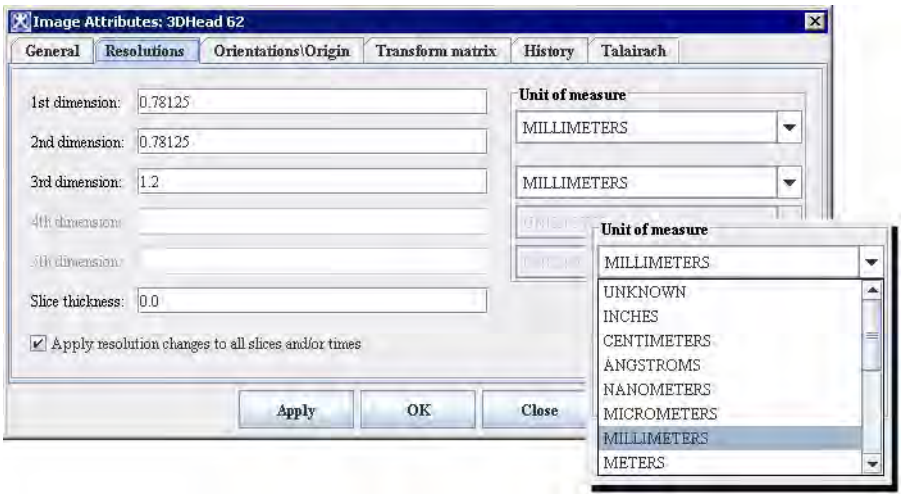


Image name (without suffix)	displays the name of the current image. You can change the image's name here.

Figure 60. The Image Attributes dialog box options

Image modality	shows image modality. You can change the modality by selecting it from the list.
The list includes:	Unknown Modality, Biomagnetic Imaging, Color Flow Doppler, Computed Radiography, Computed Tomography, Diaphanography, Digital Radiography, Duplex Doppler, Endoscopy, External Camera Photography, FA, General Microscopy, Hardcody, ICG, Intraoral Radiography, Laser Surface Scan, Magnetic Resonance Angiography, Mammography, Magnetic Resonance, Nuclear Medicine, Other, Positron Emission Tomography, Panoramic X-ray, Radio Fluoroscopy, Radiographic Imaging, Radiotherapy Dose, Radiotherapy Image, Radiotherapy Plane, Radiotherapy Record, Radiotherapy Structure Set, Red Free, Slide Microscopy, Single Photon Emission Computer Tomography, Thermography, Ultrasound, and X-ray Angiography.
Image endian order	Here, use the appropriate radio button to set the image endiannes.
Resolutions tab	



1–5 dimension	shows resolution for each dimension.
Slice thickness	shows the slice thickness.
Units of measure	displays the units of measure used in the image.
Orientation/Origin tab	

Figure 60. The Image Attributes dialog box options (continued)

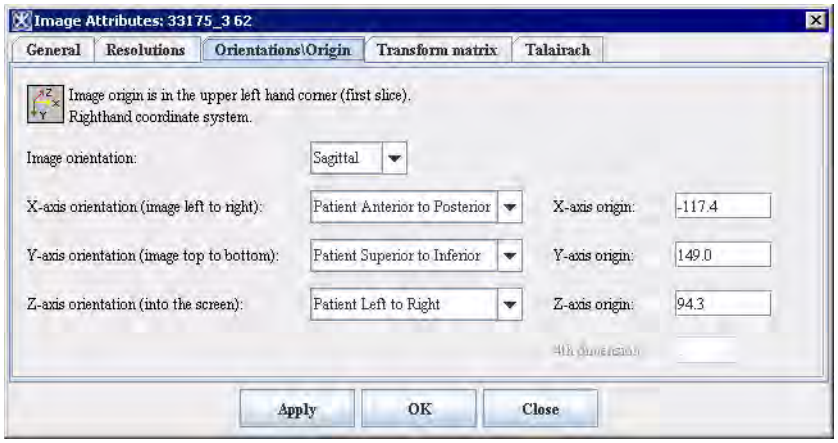
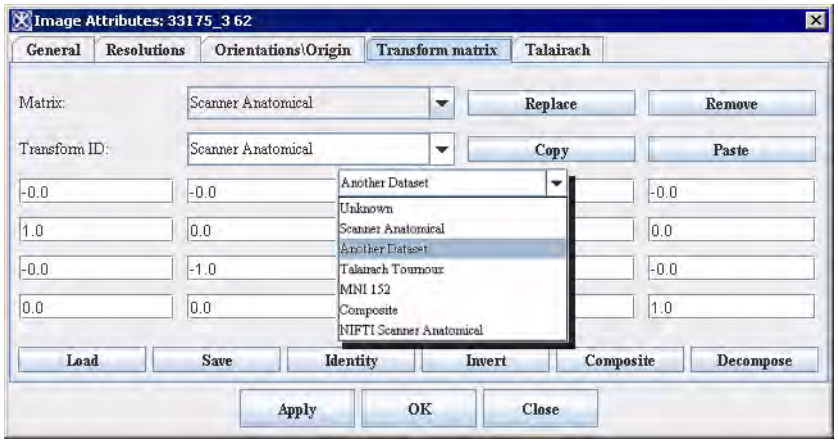


Image Orientation	Medical image data are stored in a variety of ways. In order to orient a two-dimensional image slice or three-dimensional volume in space, one needs to know how the order of the image data relates to a standard set of axes. For medical imaging, these axes are generally chosen to correspond to the directions **posterior / anterior**, **superior / inferior** and **left / right**. This information could be found from the image header. To change image orientation, select one from the list: Axial, Coronal, Sagittal, or Unknown. See also “About medical image coordinate systems.”
X-axis orientation (image left to right) **Y-axis orientation (image top to bottom)** **Z-axis orientation (into the screen)**	To specify X, Y, or Z -axis orientation, select one from the list: Unknown, Patient Right to Left, Patient Left to Right, Patient Anterior to Posterior, Patient Posterior to Anterior, Patient Inferior to Superior, Patient Superior to Inferior. Here, • The head end is referred to as the **superior end**, while the feet are referred to as the **inferior end.** • **Anterior** refers to the “front” of the individual, similarly, **posterior** refers to the “back” of the individual. • Left and right are self explanatory.
X-axis origin **Y-axis origin** **Z-axis origin**	The image origin is generally at the corner of the image, often the upper left, the axis directions are: the X- axis is across, Y -axis is down, and Z-axis goes into the screen. Usually, it differs from matrix coordinates and Cartesian coordinates. To align image coordinates with Cartesian coordinates you should specify origins for X, Y, and Z -axis.
4-th dimension	For 4D images, it specifies the units and values used for the 4-th dimension.
Transform matrix	

Figure 60. The Image Attributes dialog box options (continued)



Matrix	displays a list of transformation matrix for the chosen image
Transform. ID	displays transformation ID type for the chosen image. To change the current transformation matrix, select a new transform ID first, and then click Replace. This will replace the transformation matrix.
Replace	replaces a current transformation matrix to a new one that you choose.
Add a New	adds a transformation matrix that has been selected from the Transform ID list to the image.
Rename	renames a transformation matrix.
Copy	copies the current transformation matrix to the Clipboard.
Paste	pastes a copied transformation matrix.
Load	loads a transformation matrix (from a file with the **.mtx* extension)
Save	saves a transformation matrix to a file.
Identity	transforms the current transformation matrix to an identity matrix.
Invert	inverts the current transformation matrix.
Composite	TBD.
Decompose	TBD.
Talairach	

Figure 60. The Image Attributes dialog box options (continued)

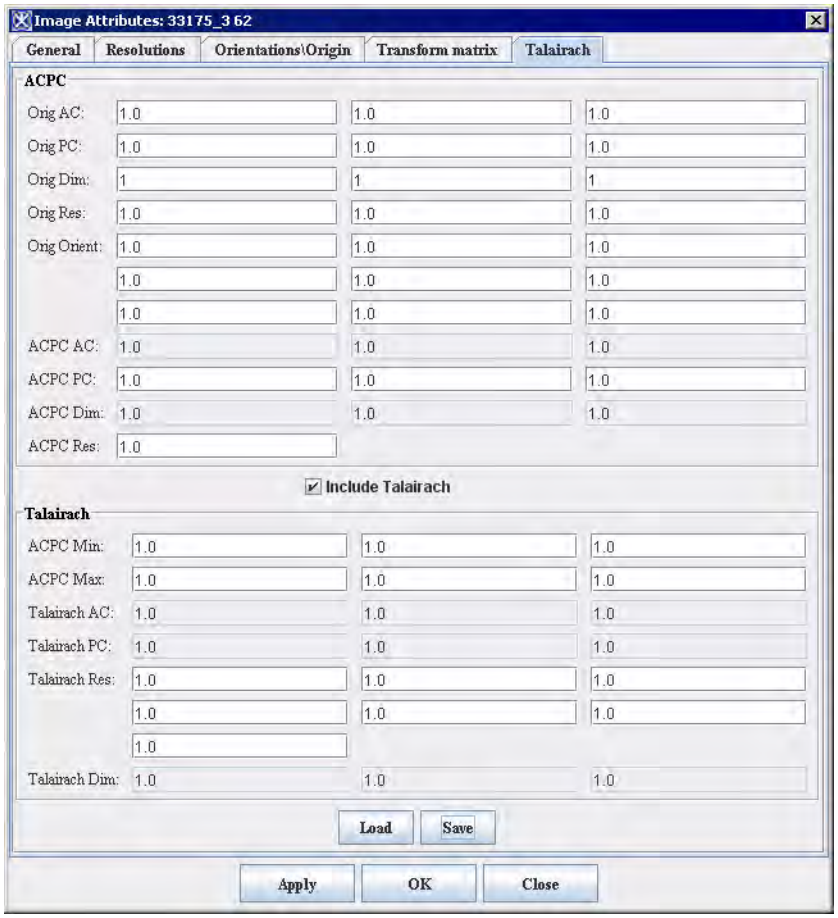
Shows ACPC and Talairach transformation matrices	
Include Talairach – displays a Talairach transformation matrix for the image.	
Load – loads a new matrix.	
Save – saves a matrix to a file.	

Figure 60. The Image Attributes dialog box options (continued)

To modify the name of the image dataset

1. Open either a DICOM or non-DICOM image dataset.
2. Select Image > Attributes > Edit Attributes in the MIPAV window. The Image Attributes dialog box opens.
3. Select the name of the image in the Image name (without suffix) box.
4. Type a new name of the image.
5. Click either Apply or OK. The new image name appears in the header on the image window.

What's the Difference Between Clicking Apply or Clicking OK?

Click Apply when you want the dialog box or window to remain open after it makes the change so that you can make further modifications. If instead you click OK, the dialog box or window closes immediately after making the current change.

To edit the dimensions and units of measure

1. Open either a DICOM or non-DICOM image dataset.
2. Select Image > Attributes > Edit Attributes in the MIPAV window. The Image Attributes dialog box opens.
3. Click Resolutions. The Resolutions page in the Image Attributes dialog box appears.
4. Type the changed values in the dimension text boxes on the left and then select the appropriate value in the Unit of measure boxes on the right.
5. Click either Apply or OK.

To edit the *x*, *y*, and *z* orientations of image datasets

1. Open either a DICOM or non-DICOM image dataset.
2. Select Image > Attributes > Edit Attributes in the MIPAV window. The Image Attributes dialog box opens.
3. Click Orientations. The Orientations page (Figure 60) in the Image Attributes dialog box opens.
4. Select the appropriate values in the boxes on the right.
5. Click Apply or OK.

To change the origin for the first image slice

1. Open either a DICOM or non-DICOM image dataset.
2. Select Image > Attributes > Edit Attributes in the MIPAV window. The Image Attributes dialog box opens.
3. Click Orientation. The Orientation page (Figure 60) in the Image Attributes dialog box appears.

4 Type the appropriate values in the dimension boxes.

5 Click Apply or OK.

To change the transform matrix

1 Open either a DICOM or non-DICOM image dataset.

2 Select Image > Attributes > Edit Attributes in the MIPAV window. The Image Attributes dialog box opens.

3 Click Transform Matrix. The Transform Matrix page (Figure 60) in the Image Attributes dialog box appears.

4 Select the appropriate transform ID in the Transform ID box.

5 Load and save transform matrices.

6 Click Apply or OK.