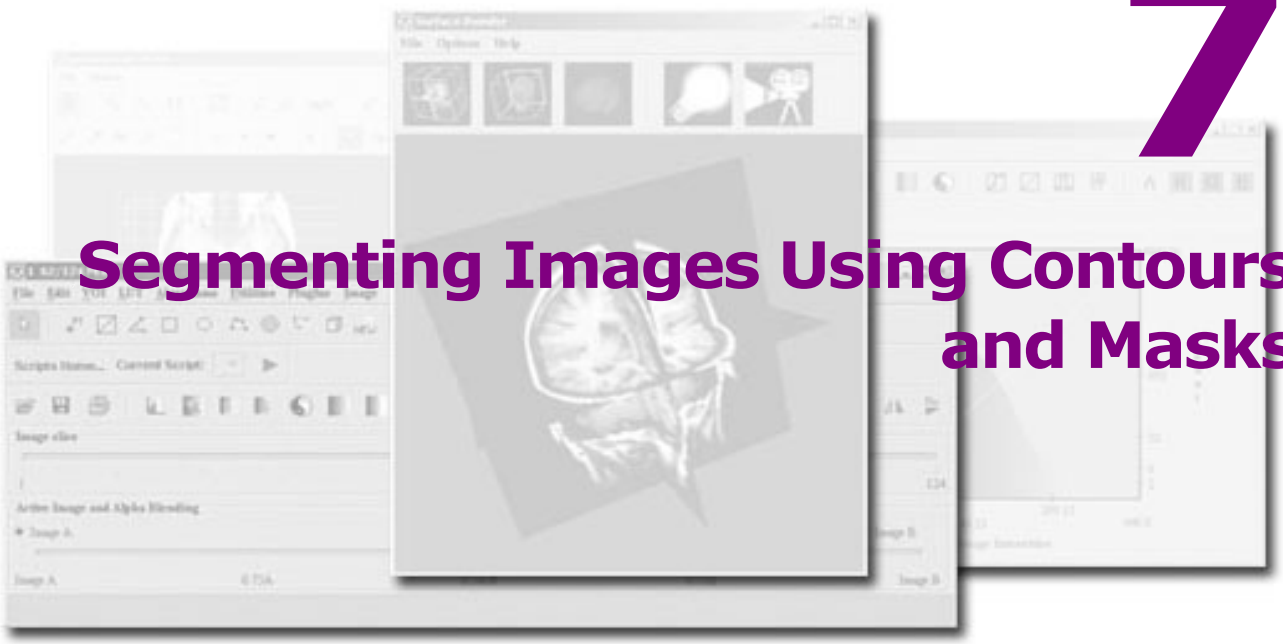


7 Segmenting Images Using Contours and Masks

In this chapter . . .

"Understanding contours and masks" on page 277
"Using contours to segment a VOI" on page 277
"Generating masks" on page 299
"Converting VOI contours to masks" on page 316
"Converting masks to VOI contours" on page 317

Segmentation is the process of identifying selected regions of images as members of a common group. Physicians routinely segment structures in medical images to facilitate the treatment of patients. The quantification of important attributes, such as the volume of various tissue types, enables researchers to better understand, diagnose, monitor, and treat neurobehavioral disorders.

MIPAV provides several segmentation tools that allow you to delineate a volume of interest (VOI). You can indicate a VOI by drawing a contour or by creating a mask. You can also calculate predefined statistics on the indicated VOI.

Note: Once a VOI is segmented, you can also apply an algorithm to the volume bound by the contours. MIPAV provides a number of algorithms, such as Gaussian blur, Laplacian, threshold, and watershed. These algorithms and others are addressed in detail in volume 2 of the *User's Guide*.

Understanding contours and masks

Before you indicate a volume of interest, it is helpful to determine whether to delineate the VOI by drawing a contour around a structure or to generate a mask.

A *contour* is an array of points. If the contour is a closed polygon, the area inside defines the VOI. Contours are scalar and can be grouped to form a single multicontoured VOI. Contours are particularly useful if you want to save a VOI that covers a large area because the resulting file is generally smaller than a comparable mask file.

A *mask* is a filter that selectively includes or excludes certain values. You can create a mask that includes the VOI areas and excludes all other areas. Masks are particularly helpful if you use other image analysis programs that require you to supply a mask. Masks are also helpful if you need to indicate a complex area of interest. MIPAV allows you to generate binary and short image type masks. Also, you can manually create masks using paint tools.

Using contours to segment a VOI

A VOI can consist of a single contour or several contoured structures that are assigned to a group. You can automatically, manually, or interactively draw contours on any image that is shown in the default view. You can modify the shape and size of a contour and trim anchor points. Once contours are drawn and modified, you can copy them to other slices in the dataset or save them to a separate file for future use.

The three overall tasks involved in using contours to segment a VOI are:

- Drawing contours ("Drawing contours" on page 278)

- Modifying contours (“Modifying contours” on page 287)
- Grouping and ordering contours (“Grouping and ordering contours” on page 292)

Drawing contours

You can draw contours using three different methods: manual, interactive, or automatic. With the *manual method*, you use the mouse to draw a contour. This method provides the greatest amount of freedom: you can choose one of MIPAV’s predefined shapes or create a freehand shape. However, the manual method can be time consuming, particularly if the structure to be contoured is intricate. With the *interactive method*, you must also manually contour the structure. However, in this case the manually drawn contour need not be precise because you then apply an algorithm that generates a new contour based on both the manually drawn contour and the structure. With the *automatic method*, MIPAV generates contours as you move the mouse over different structures. The automatic method is generally accurate and quick; however, it does not provide the freedom of the manual method.

Recommendation. If you are unsure about which contour method to use, it is recommended that you try the automatic method first.

Contouring structures automatically

In this method, you move the mouse pointer over a structure. MIPAV first analyzes the intensity values and then contours what it perceives to the contour boundary.

Complete the following steps:

1. Select VOI > New VOI > Levelset in the MIPAV window.
2. Move the mouse pointer to the image.

   The pointer changes to the cross-hair shape. As you move the pointer, MIPAV determines the level of intensity of the pixel under the cross-hair pointer and uses the results from the Levelset algorithm to determine the probable boundary of the structure. Having determined

the probable boundary, MIPAV generates a contour (Figure 195). Continue to move the pointer until the structure you wish to outline is contoured.

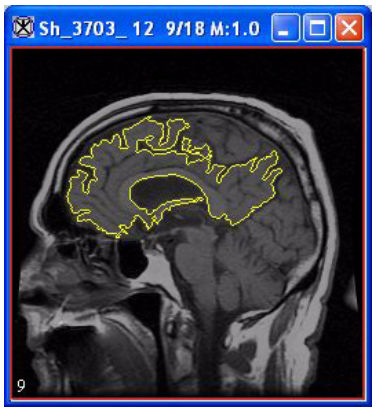


Figure 195. Automatically generated contour

3 Click the contour to apply it to the structure.

4 You can now do the following:

- Draw an additional contour
- Modify the contour
- Reassign an existing contour to a different group
- Order the contours
- Delete the contour

CONTOURING STRUCTURES MANUALLY

You can contour structures in images by selecting one of MIPAV's predefined shapes, such as a point, straight line, 2D or 3D rectangle, and 2D ellipse. Alternatively, you can use the polygon and polyline tools to draw freehand shapes. This section explains how to draw the following:

- Point VOIs
- VOIs with a straight line
- 2D rectangular VOIs

- 3D rectangular VOIs
- Ellipsoidal VOIs
- Polyline (segmented line) and closed polygon VOIs

Tip: Before you begin, decide whether you want to draw more than one of the same contour in succession. If you do, hold down the Shift key as you select the contour button and draw the contours.

To draw point VOIs

1. Select , the Draw point VOI button, in the MIPAV window.
2. Move the pointer to the image.
3. Click the area where you want the point to appear. A numbered point appears on the image.

Note: For some algorithms, the sequence in which you draw the points is important (refer to volume 2 of the *User's Guide*).

To create VOIs with a straight line

1. Click , the Draw line VOI icon.
2. Click the area on the image where you want the line to begin.
3. Drag the pointer to the place where you want the line to end. As you drag the pointer, the line lengthens.
4. Release the mouse button. The line VOI appears on the image in red (Figure 196).

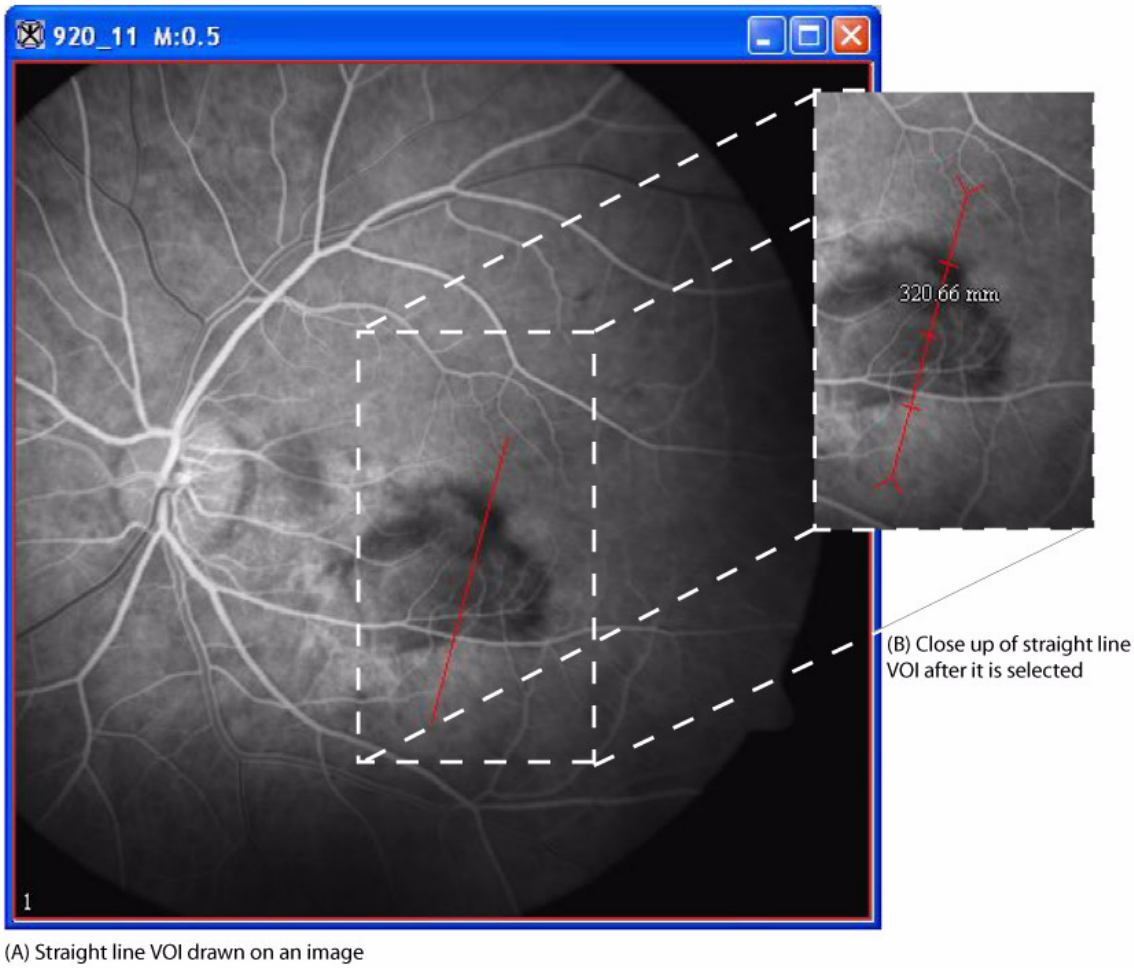


Figure 196. VOI with straight line

To create 2D rectangular VOIs

1. Click , the Draw rectangle VOI icon.
2. Click the area on the image where you want a corner of the rectangle to appear.
3. Drag the pointer. As you drag the pointer, the rectangle changes in size.
4. Release the mouse button when the rectangle is the desired size.

Note: When you create a 2D rectangular VOI, the rectangles appear on only one slice in the dataset.

To create 3D rectangular VOIs

1. Click , the 3D rectangular VOI icon.
2. Click the area on the image where you want a corner of the rectangle to appear.
3. Drag the pointer. As you drag the pointer, the rectangle changes in size.
4. Release the mouse button when the rectangle is the desired size.

Note: Unlike 2D rectangular VOIs, 3D rectangular VOIs appear on *all* slices in the dataset.

Figure 197. Example of a 3D rectangular VOI

To create ellipsoidal VOIs

1. Click , the Draw ellipse VOI icon.
2. Click the area of the image where you want an edge of the ellipse to appear.
3. Drag the pointer. As you drag the pointer, the ellipse changes in size.

4 Release the mouse button when the ellipse is the desired size (Figure 198).

Figure 198. Ellipsoidal VOI

To create polyline (segmented line) VOIs or closed polygon VOIs

1 Click , the Draw polygon/polyline VOI icon.

2 Click the area of the image where the polyline VOI should begin.

3 Decide whether to draw either a straight or freehand line segment. Do one of the following:

- *To draw a straight line segment*

  a Make sure that you have released the mouse button.

  Move the pointer to the place where you want the segment to end. A straight line, which extends from the starting place to your pointer tip, appears.

  Click the mouse button to anchor the line segment.

- *To draw a freehand line segment*

  a Drag the mouse button and move the pointer to the place on the image where you want the segment to end. A line, which matches your mouse movements, extends from the starting place to your pointer tip.

  Click the mouse button to anchor the line segment.

4 Repeat drawing straight line segments or freehand lines until you finish drawing all of the segments needed to contour the structure.

5 Decide whether to create a polyline VOI or a closed polygon VOI:

- *Polyline VOI:* Go to the next step.
- *Closed polygon VOI:* Click the first anchor point to connect the last line segment to the first, thus forming a closed polygon. Then go to the next step.

6 Click , the Default icon, to return the pointer to the default mode.

Tip: Depending on which is more comfortable, you can switch between drawing straight line segments or drawing freehand lines at any time.

7 Double-click the mouse button to complete the polyline VOI (Figure 199).

Figure 199. Polyline VOI (A) and closed polygon VOI (B)

CONTOURING STRUCTURES INTERACTIVELY

In the interactive method, you first manually draw a contour that provides a general indication of the location and shape of the structure. You then select an algorithm that analyzes the manually drawn contour and generates a new one that more closely outlines the structure.

To use the interactive method to contour structures, complete the following steps:

1. Draw a contour using one of the manual methods detailed in "Contouring structures manually" on page 279. The contour need not be precise, but it should indicate the general location and shape of the structure you want to delineate.
2. Select the contour. White anchor points appear on the contour outline.
3. Select one of the following in the MIPAV window:
   - *VOI > Evolve Boundary 2D > Active Contour*. This algorithm determines the structure's boundary more quickly than the 2D Spline Active Contour algorithm. It is also more sensitive to noise present in the image. MIPAV applies a gradient magnitude filter to determine the structure's boundary. When complete, the MIPAV-generated contour appears around the structure.
   - *VOI > Evolve Boundary 2D > Active GVF*. [TBD]
   - *VOI > Evolve Boundary 2D > Spline active contour*. This algorithm determines the structure's boundary less quickly than the Active Contour algorithm and is less sensitive to noise. This algorithm fits a spline to the data. When complete, the MIPAV-generated contour appears around the structure.
   - *VOI > Evolve Boundary 2D > Spline GVF*. [TBD]
4. Select one of the following options:
   - Draw an additional contour
   - Modify the contour
   - Delete the contour

Modifying contours

Once contours are drawn, you can reposition, resize, or reshape them. You can also trim anchor points.

Repositioning contours

You can reposition a single contour or a group of contours. Follow the instructions below.

To reposition a single contour

Select the contour and drag it to the new location.

To reposition a group of contours

1. Hold down the Shift key as you click one of the contours in the group. All of the other contours in the group are also selected.
2. Continue to hold down the Shift key as you drag the contour group to the new location.

Resizing contours

You cannot collectively resize a group that consists of multiple contours; each contour must be resized individually. Except for point VOIs, you can resize any contour shape. For lines, only the length can be changed; the width cannot.

Before you can resize them, all contour shapes except lines must be surrounded by a bounding box. Go to the following section “To turn the bounding box on”.

To resize lines, go to “To resize contours”.

To turn the bounding box on

1 Do either of the following:

- Select the contour and then select VOI > Properties in the MIPAV window.
- Right-click the contour. A menu appears. Select Properties.

The VOI Statistics dialog box (Figure 200) opens.

2 Select Show contour bounding box.

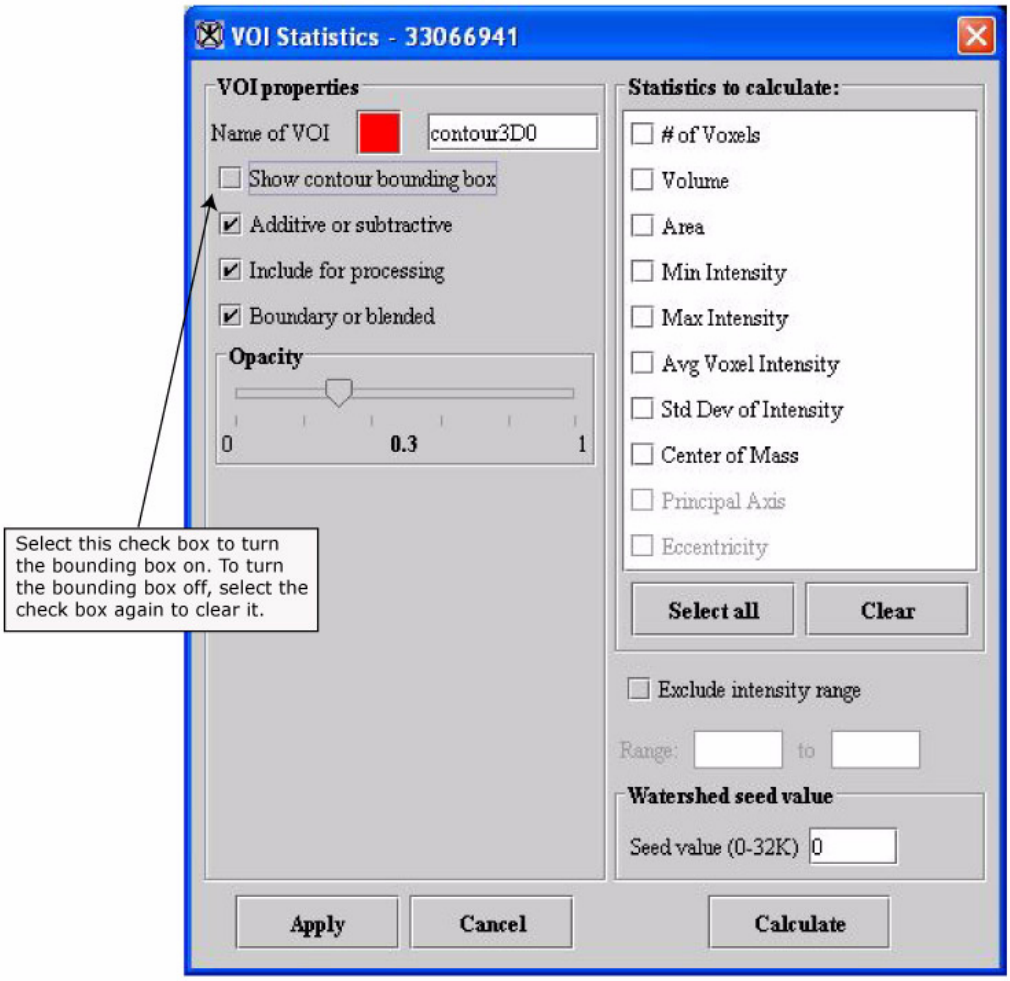


Figure 200. VOI Statistics dialog box

3 Change, if you want, any of the other information in the dialog box.

4 Click Apply.

5 Click Cancel to close the dialog box.

To resize contours

1 Select the contour. The bounding box appears (Figure 201) around the shape. (For rectangle contours, the bounding box and rectangle legs may overlap.)

2 Click Cancel to close the window.

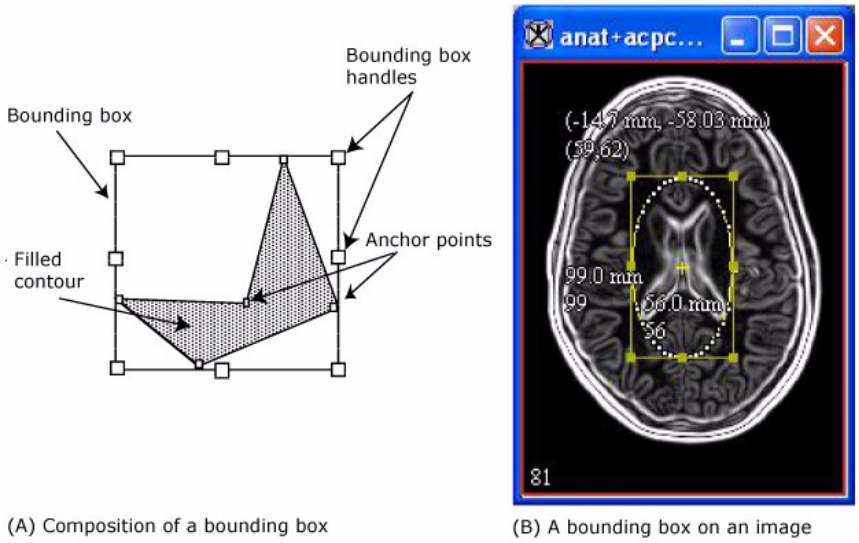


Figure 201. Examples of a bounding box

3 Do one of the following:

- *To resize lines:* Click an edge or corner of the shape. Drag until the shape is the desired size.
- *To size other shapes:* Click one of the bounding box handles. Drag the handle until the shape is the desired size.

4 Choose whether to continue showing the bounding box.

Note: If you want to reposition or add an anchor point, turn the bounding box option off.

To turn the bounding box off

1. Do one of the following:
   - Right-click the contour. Select Properties from the pop-up menu.
   - Left-click the contour. Select Properties from the VOI menu in the MIPAV window.

   The VOI Statistics dialog box appears (Figure 200 on page 288).
2. Clear Show Contour Bounding Box.
3. Click Apply.
4. Click Cancel to close the window.

RESHAPING A CONTOUR

You reshape the contour by adding or repositioning anchor points. Instructions for adding and repositioning anchor points follow.

To add anchor points

1. Click the contour to select it. The anchor points become visible.
2. Click the place where you want to add the new anchor point. The new anchor point appears.

To reposition anchor points

You can reposition a single anchor point at a time. If you need to redraw a portion of the contour, MIPAV allows you to reposition several contiguous anchor points with one motion of the mouse.

1. Select the contour. The anchor points become visible.
2. Position the pointer over the anchor point or points that you want to reposition. The pointer changes to the shape of a hand with the index finger extended.

3 Do either of the following:

- *To reposition a single anchor point:* Drag the anchor point to the new location.
- *To reposition several anchor points:* Hold down the Alt key as you drag the anchor points in the counterclockwise direction to their new locations.

TRIMMING VOI ANCHOR POINTS

MIPAV can automatically trim anchor points from the contour. In the trimming process, unnecessary anchor points are pruned. For example, if three anchor points are on the same line, the middle anchor point is deleted. Since only two anchor points are needed to indicate a line, the middle anchor point is extraneous. The trim parameter defines what is meant by the *same line*. Setting this value to zero causes only unnecessary anchor points on a straight 180-degree line to be pruned. Setting a higher value prunes all but the sharpest corners of the contour.

To trim anchor points

1 Select the contour you want to trim.

2 Select VOI > Trim Parameter in the MIPAV window. The VOI Trim Parameter dialog box (Figure 202) opens.

3 Move the slider to the desired number.

Trim parameter	Specifies the number of anchor points you want the software to trim from the contour. Setting this value to zero causes only unnecessary anchor points on a straight 180-degree line to be pruned. Setting a higher value prunes all but the sharpest corners of the contour.
Trim adjacent points	Trims points that are adjacent.
Apply	Applies the parameters that you specified.

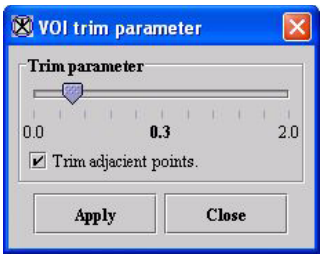


Figure 202. VOI trim parameter dialog box

Close	Disregards any changes that you made in this dialog box and closes the dialog box.
Help	Displays online help for this dialog box.

Figure 202. VOI trim parameter dialog box

4 Click Apply. The software removes all unnecessary anchor points.

5 Click Close to close the dialog box.

Grouping and ordering contours

The final step in the segmentation process is to group and order contours. The group, which can be composed of one or more contours, is commonly referred to as a VOI. Grouping can be an important component of the segmentation process.

Example: A researcher might contour several structures. The researcher might then assign each contour to the gray.voi (gray matter), white.voi (white matter), or cerebfl.voi (cerebrospinal fluid) group. If groups overlap, the researcher can indicate which group should appear in the foreground by reordering the groups.

Grouping contours

A group may consist of one or more contours. A contour is assigned to only one group. When a contour is initially drawn or generated, MIPAV assigns it to a default group. MIPAV also assigns default group properties, such as color and name. Each contour inherits the properties of its assigned group. At any time, you can change the properties of a group or its members (contours).

To change the group with which a contour is affiliated

1 Right-click the contour you wish to modify.

2 Select Properties. The VOI Statistics dialog box (Figure 200) opens.

The name of the VOI appears in the Name of VOI text box. A colored box appears beside the text box.

To change group properties

1. Select the colored box on the VOI Statistics dialog box. The Pick VOI Color dialog box opens.
2. Click OK to apply the color to the grid/border. The Pick VOI color dialog box closes.
3. Click OK.
   - To change the name of the VOI, modify the name in the text box next to the Name of VOI colored box.
   - To adjust the opacity, move the slider in the Opacity panel. The number in the center indicates the current value; 0 is transparent and 1 is opaque.

ORDERING CONTOURS

If two or more contours overlap, MIPAV organizes them so that they appear one on top of the other, much like a stack of papers on a desk. This is often not readily apparent because by default, when contours are drawn, they are transparent and only the outlines are visible. Thus, if two contours overlap, all parts of each contour, except the areas where the outlines overlap, can be seen.

To fill contours

1. Right-click the contour.
2. Select Properties. The VOI Statistics dialog box opens.
3. Clear the Boundary or Blended check box to remove the check mark.
4. Click Apply.
5. Close the VOI Statistics dialog box. The contour is filled with the default paint color. To change the paint color, refer to “Manually creating a mask using paint” on page 301.

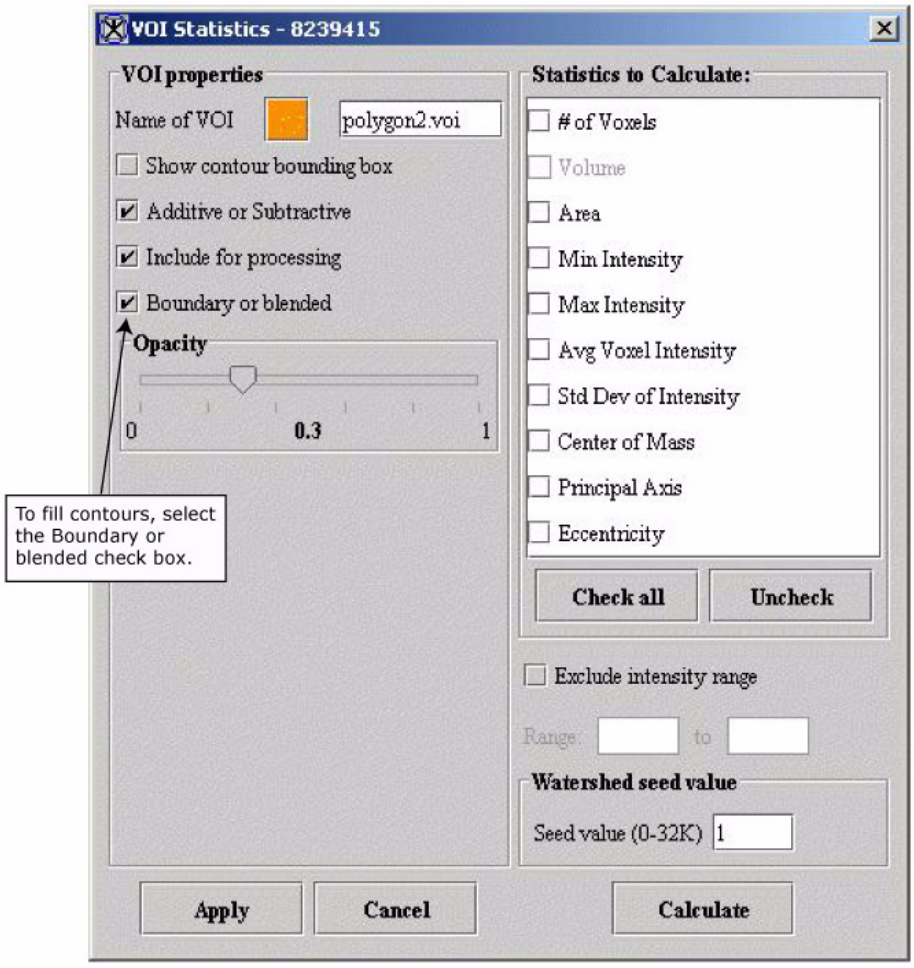


Figure 203. Boundary or blended check box in the VOI Statistics dialog

To reorder contours

1. Click the contour to be reordered.
2. Select VOI > Order in the MIPAV window. Then select one of the following commands:
   - *Bring to Front:* Moves the contour in front of all of the other contours.
   - *Send to Back:* Moves the contour behind all other contours.

- *Bring Forward:* Moves the contour forward one position. For example, if you select this command and the contour is the third contour in a stack of five contours, the contour is moved to the second position in the stack.
- *Send Backward:* Moves the contour backward one position. For example, if you select this command and the contour is the third contour in a stack of five contours, the contour is moved to the fourth position in the stack.

The software reorders the contours according to the command.

Copying, cutting, and pasting VOIs

You can undo, cut, copy, and paste a VOI within the image, to another slice in the image dataset, or to another image dataset.

To undo a VOI

1. Select the VOI.
2. Select Edit > Undo VOI (Figure 204) in the MIPAV window. The software removes the VOI from the image.

To cut a VOI

1. Select the VOI.
2. Select Edit > Cut VOI (Figure 204) in the MIPAV window. The software copies the VOI to the clipboard and deletes it from the window.

Tip: You can also remove a VOI by pressing the Del key after selecting the VOI.

To copy a VOI

1. Select the VOI.
2. Select Edit > Copy VOI (Figure 204). It is copied to the clipboard.

Figure 204. Undo VOI, Cut VOI, Copy VOI, and Paste VOI commands on the Edit menu in the MIPAV window

To paste a VOI

1. Select the VOI that you want to paste.
2. Select Edit > Copy VOI to copy the VOI to the clipboard.
3. Do one of the following:
   - Navigate to another slice in the dataset using either , the Increments image slice icon, or , the Decrements image slice icon.
   - Open another image dataset.
4. Select Edit > Paste VOI (Figure 204). The program copies the VOI from the clipboard and pastes it into the image.

You can only copy and paste one, not multiple, VOIs into another slice using the Paste command. Also, note that the software pastes a copied VOI into the image at exactly the place from which it was copied.

To copy multiple VOIs to the next or previous slice in the dataset

1. Select all of the VOIs that you want to copy.
2. Do one of the following:
   - Click , the Propagate VOI up icon, to copy the VOI to the next slice.
   - Click , the Propagate VOI down icon, to copy the VOI to the previous slice.
   - Click , the Propagate VOI to all slices icon, to copy it to every image in the dataset.

Deleting VOIs

You can easily delete a VOI or one of its contours.

To delete a VOI

1. Select the VOI or one of its contours.

   To delete a VOI that consists of many contours, hold down the Shift key and then click one of the contours in the VOI group.
2. Do one of the following:
   - Right-click on the VOI, and then select Edit > Delete (Figure 205).
   - Select Edit > Delete VOI in the MIPAV window.

   The software removes the VOI or contour.

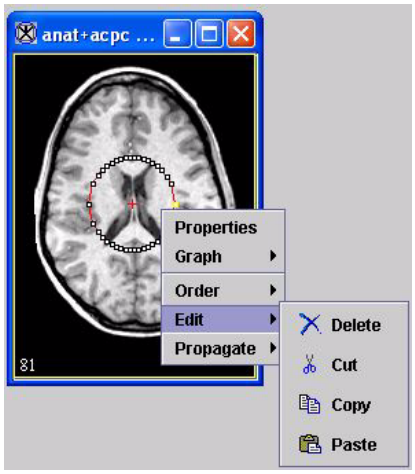


Figure 205. Delete command on the pop-up menu

Saving and opening VOI files

You can save a VOI to a text file. This file can then be opened and applied to the same dataset or a different one, or it can be manipulated using a word processor.

To save a single VOI as a text file

1. Select a contour or a VOI.
   - To select a contour, click on it.
   - To select a VOI, hold down the Shift key and select a contour. All contours that are part of the VOI are selected.
2. Do either of the following:
   - If you want the software to automatically name the file, select VOI > Save VOI in the MIPAV window. The software saves the file with a .XML extension.
   - If you want to assign the file name, select VOI > Save VOI as. The Save as dialog box appears.
     a. Type the name of the VOI file in the File Name box. Be sure to use either the .VOI extension or the .XML extension.
     b. Click Save. The software saves the file under the specified name.

To save multiple VOIs

Do either of the following:

- To allow the software to automatically name the file, select VOI > Save All VOIs.
- To assign a file name to the file, select VOI > Save All VOIs as.

  a Type the name of the VOI file in the File Name box. Be sure to use either the .VOI extension or the .XML extension.

  b Click Save. The software saves the file under the specified name.

To open saved VOI files

1. Select the image window of the dataset to which you want to apply the VOI.
2. Select VOI > Open VOI in the MIPAV window. The Open dialog box appears.
3. Select the file or files and then click Open. The VOI or VOIs appear in the image window.

Note: If you make a change to the VOI and want to make a change to the file, select VOI > Save VOI in the MIPAV window. The changes are saved to the VOI file.

Generating masks

A *mask* is a filter that selectively includes or excludes certain values. You can create a mask that includes the VOI areas and excludes all other areas. Masks are particularly helpful if you use other applications to further analyze images because those programs may require that you supply a mask. An example of a mask appears in Figure 206.

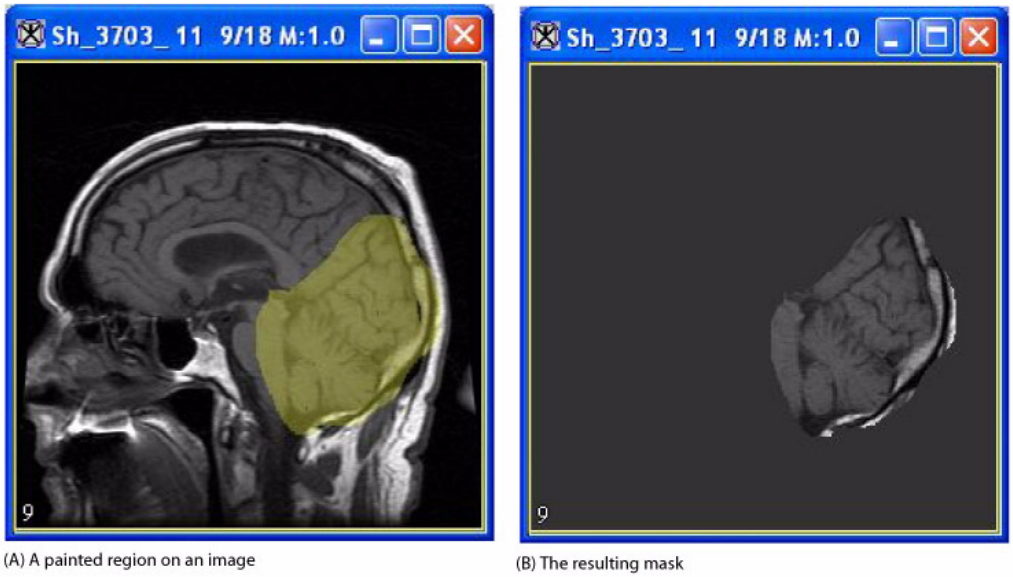


Figure 206. Image with (A) a painted region and (B) the resulting mask

You can create masks using a variety of methods:

- Use paint tools to manually create a mask
- Use Paint Grow Segmentation tool
- Use binary or short mask utilities

MIPAV also provides algorithms that you can use to generate masks. These algorithms are addressed in volume 2 of the *User's Guide*.

Manually creating a mask using paint

You can manually create a mask using the tools on the Paint toolbar, which is located in the MIPAV window. To create the mask, you first select the intensity level of the paint, along with the paint color and opacity value. Next, you paint on the image using the paint brush. You can adjust the size of the paint brush tip. When complete, you then commit the paint by choosing one of the following icons:

- , the Changes image where painted inside icon
- , the Changes image where painted outside icon

When you click one of these icons, it applies the intensity permanently to the image. You can then choose to save the image.

Figure 207. Paint toolbar

If the Paint toolbar does not appear in the MIPAV window, select Toolbars. The Toolbar menu lists four commands: VOI Toolbar, Paint Toolbar, Scripting Toolbar, and Image Toolbar. If a toolbar command has a check mark next to it, the toolbar is displayed; otherwise, it is hidden. To display the Paint toolbar, select Paint Toolbar.

Manually generating a mask includes the following four steps:

- Step 1, Selecting the paint intensity level
- Step 2, Selecting a paint color
- Step 3, Adjusting the opacity level of the paint
- Step 4, Applying the paint

STEP 1, SELECTING THE PAINT INTENSITY LEVEL

The first step in manually creating a mask is to select the intensity level of the masked area.You can select the intensity level by using the eyedropper tool to select an intensity value that is already present in an image or by typing a specific intensity value in the Desired Paint Intensity dialog box.

To select the intensity level using the Eyedropper tool

The Eyedropper tool allows you to copy an intensity level that is already present in the image. To use this tool, complete the following steps:

1. Click , the Eyedropper icon, on the paint toolbar in the MIPAV window.
2. Click the area of the image that has the intensity level you want to copy.

   The intensity level button, , changes to the intensity level in the part of the image you selected.

Example: Initially, the intensity level button shows a zero on the button, . However, when you click an area of the image, it displays the number that is associated with that part of the image, such as 250, .

To select the intensity level using desired paint intensity

You can enter a specific intensity level value in the Desired Paint Intensity window. To do this, complete the following steps:

1 Click 0, the Intensity button.

Note: If you changed the intensity level using the eyedropper or this button previously in your current MIPAV session, the number on the Intensity button would have changed from 0 to the number representing that earlier intensity level.

The Desired Paint Intensity dialog box opens (Figure 208).

2 Notice that the minimum and maximum intensity values appear in parentheses. These values depend on the image type, or data type, of the image.

Tip: You can look at the exact intensity levels in the image using , the Magnify region icon.

Intensity	Specifies the intensity, or strength, of the paint.
Apply	Applies the intensity that you specified to the image.
Cancel	Disregards any changes that you made in this dialog box and closes the dialog box.
Help	Displays online help for this dialog box.

Figure 208. Desired Paint Intensity dialog box

3 Type the desired level of intensity.

4 Click Apply to apply the intensity level to the paint. Note that the number on the Intensity button changes to the number you entered.

5 Click or Cancel to close the dialog box.

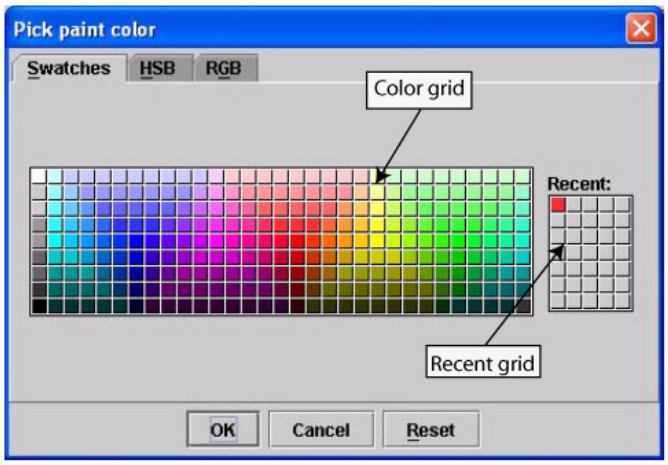
STEP 2, SELECTING A PAINT COLOR

After you select the intensity level, the next step is selecting the paint color. The program applies this color to the image so that you can easily see where you applied the new intensity. When you commit the changes to the image, the grayscale intensity level that you indicated in step 1 is permanently applied to the image.

To select a color, use , the Change Paint Color icon, to display the Pick Paint Color dialog box (Figure 210). This dialog box includes three tabbed pages: Swatches page, which is always displayed first; the HSB page; and the RGB page. You can select a color on any of the pages.

To select a color from one of the 310 color swatches

1. Click , the Change Paint Color icon. The Pick Paint Color dialog box (Figure 209) opens.
2. Stay on the Swatches page, or, if you moved to HSB or RGB pages, click Swatches to return to the Swatches page.
3. Click the desired color in the larger grid. The color appears in the Recent color grid on the right.
4. Click Close when done. The Pick Paint Color dialog box closes. The color you selected becomes the current paint color.

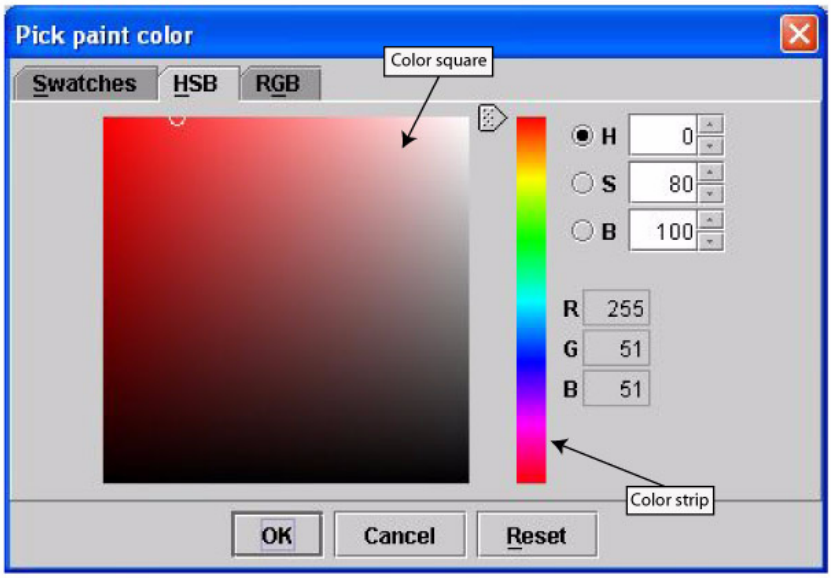


Color grid	Shows the available colors. Select one of these colors and it appears in the Recent grid on the right.
Recent grid	Indicates colors that you have recently selected from the color grid on the left. MIPAV uses the last color that you selected from the color grid and that appears in this grid as the color of the background in the lightbox view once you select OK.
OK	Applies the parameters that you specified to crop the image.
Cancel	Disregards any changes you made in this dialog box, closes the dialog box, and does not crop the image.
Reset	Returns the color settings to their previous values.
Help	Displays online help for this dialog box.

Figure 209. Swatches page in the Pick Paint Color dialog box

To select a color using the HSB model

1. Click , the Change Paint Color icon. The Pick Paint Color dialog box opens.
2. Click HSB. The HSB page appears (Figure 210B).



Color square	Specifies a specific color to be used as the background color.
Color strip	Specifies a specific color to be used as the background color.
H	Specifies the number representing the hue of the color.
S	Specifies the number representing the saturation of the color.
B	Specifies the number representing the brightness of the color.
R	Specifies the number for the color used for the red channel.
G	Specifies the number for the color used for the green channel.
B	Specifies the number for the color used for the blue channel.
OK	Applies the parameters that you specified to crop the image.
Cancel	Disregards any changes you made in this dialog box, closes the dialog box, and does not crop the image.
Reset	Returns the color settings to their previous values.
Help	Displays online help for this dialog box.

Figure 210. The HSB page in the Pick Paint Color dialog box

3 Specify a color by entering specific numbers for the hue, saturation, and brightness values, or select the color from the color graphic.

Using the Hue, Saturation, and Brightness Color Model

The HSB color model defines colors by a combination of their hue, saturation, and brightness.

The *hue* is the wavelength of light transmitted through or reflected from an object. The hue is more commonly known as *color* (such as magenta or green).

Below is the Munsell color wheel. A color strip, which is derived from the color wheel, appears as well. Hues are represented by the degrees in the color wheel. (Since colors are graduated, the degrees in the figure are approximations and not necessarily absolute values.

For example, yellow is approximately 45 degrees; 50 degrees is a different shade of yellow.

Primary colors (red, yellow, and blue) combine to create secondary colors (magenta, cyan, and green).Tertiary colors, such as orange, are also represented on the color wheel.

The color strip is simply a different representation of the color wheel. Degrees and corresponding hues were added to the figure.

Saturation is the strength or purity of the hue. To lessen the saturation, gray is added to the color. Thus, if pure orange is 70 percent saturated, the hue is a mixture of orange (70 percent) and gray (30 percent).

Brightness is the relative darkness and lightness of a color; 0% brightness is black; 100% brightness is white.

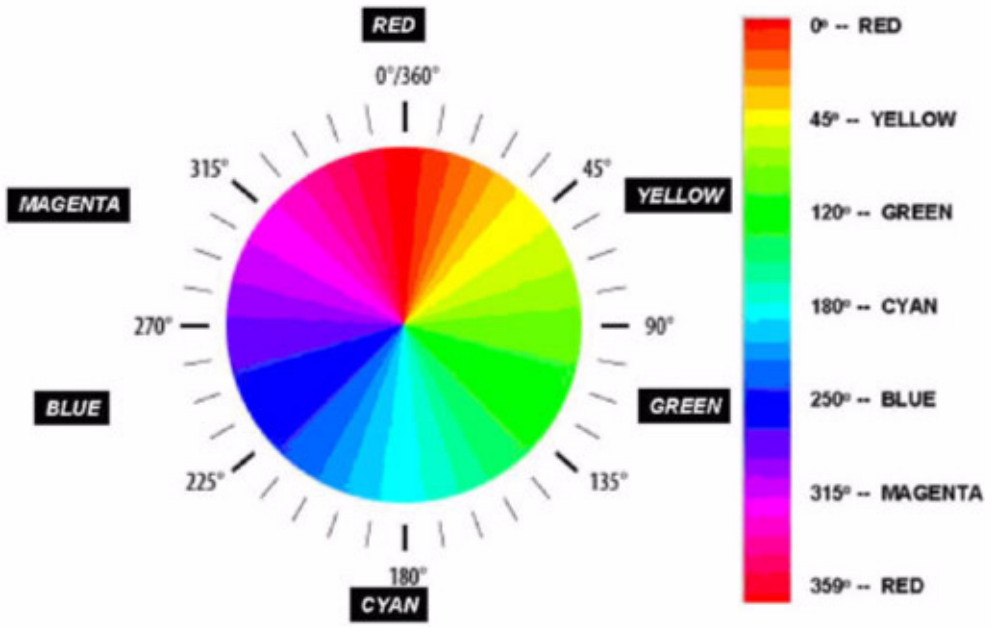


Figure 211. Munsell color wheel (left) and color strip (right)

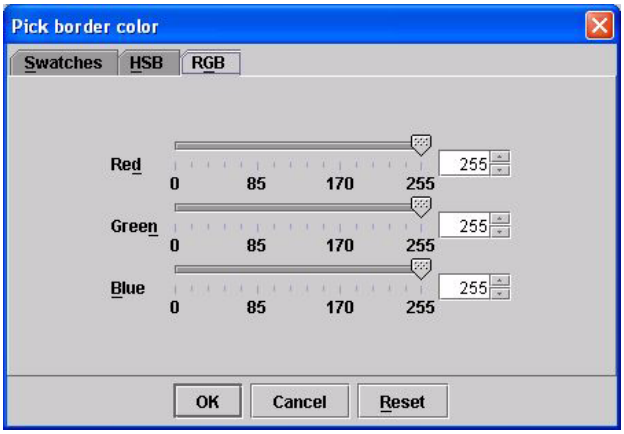
- Enter specific values into the H, S, and B boxes:
  - *Type the hue value in H*. The hue can be any number from 0 to 359. The numbers correspond to the degree numbers on the color square (Figure 211). For example, to specify a shade of blue, enter a number from 255 to 270. The slider automatically moves the correct hue on the color strip.
  - *Type the saturation value in S*. The level of saturation can be anywhere from 0 (gray) to 100 (full-strength hue). When you type a value into this box, a circle appears in the color square around the color with the specified saturation level. Colors to the left of the color graphic are circled if the saturation level is high. Lower saturated colors are found to the left of the color graphic.
  - *Type the brightness value in B*. The level of brightness can be anywhere from 0 (dark) to 100 (light). In the color graphic, a circle appears around the color with the specified brightness level. Colors near the top of the color graphic are circled if the saturation level is high. Darker colors are found near the bottom of the color graphic.
- Select the hue, saturation, and brightness on the color square or color strip:
  - Drag the slider to select the desired hue from the color strip.
  - Select the shade you wish to use in the color square.

4 Click Close when done. The Pick Paint Color dialog box closes. The color you selected becomes the current paint color.

To select a color using the RGB model

1 Click , the Change Paint Color icon. The Pick Paint Color dialog box opens.

2 Click RGB. The RGB page (Figure 210C) appears.



Red slider and list box	Specifies the number representing the red channel. Either use the slider, or select the number in the list box.
Green slider and list box	Specifies the number representing the green channel. Either use the slider, or select the number in the list box.
Blue slider and list box	Specifies the number representing the blue channel. Either use the slider, or select the number in the list box.
OK	Applies the parameters that you specified to crop the image.
Cancel	Disregards any changes you made in this dialog box, closes the dialog box, and does not crop the image.
Reset	Returns the color settings to their previous values.
Help	Displays online help for this dialog box.

Figure 212. RGB page in the Pick Paint Color dialog box

3 Specify the numbers for the three components (red, green, and blue), or use the sliders to select a color.

4 Click Close when done. The Pick Paint Color dialog box closes. The color you selected becomes the current paint color.

STEP 3, ADJUST THE OPACITY LEVEL OF THE PAINT

You can further refine the appearance of the paint selecting its opacity level. Opacity levels can range from 0.0 (transparent) to 1.0 (opaque).

To change the opacity level

1. Click Opacity on the Paint toolbar. The Paint Opacity window appears (Figure 213).
2. Drag the slider to the desired level of opacity. The current level appears in the bold print underneath the slider.
3. Click Close to apply the opacity level. The opacity level on the image changes according to your specifications.

Opacity	Specifies the degree of transparency. To make the color more transparent, move the slider to left. To make it more opaque, move the slider to the right.
Close	Closes this dialog box.

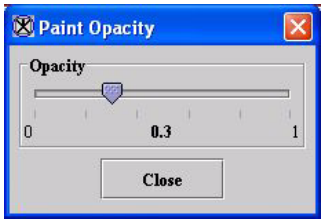


Figure 213. Paint Opacity dialog box

STEP 4, APPLY PAINT

Having selected the intensity level, paint color, and opacity level, you are now ready to paint on the image with the paintbrush.

To paint on the image

1. Click , the Paintbrush icon, on the Paint toolbar in the MIPAV window.
2. Select one of the following sizes of the paintbrush tip:

- *A 1-pixel tip:* Click , the Small size icon
- *A 16-pixel (4 x 4 square) tip:* Click , the Medium size icon
- *A 100-pixel (10 x 10 square) tip:* Click , the Large size icon

3 Click and drag the mouse button to paint on the drawing. You can select one pixel at a time, or drag the mouse button to draw paint strokes on the image.

Tip: You may need to use the magnification buttons to adjust the magnification level of the image.

If you make a mistake, you can erase or undo the painted area.

To erase paint from a specific area

1 Click , the Erase icon.

2 Select the size of the eraser tip by clicking one of the following:

- *A 1-pixel tip:* Click , the Small size icon
- *A 16-pixel (4 x 4 square) tip:* Click , the Medium size icon
- *A 100-pixel (10 x 10 square) tip:* Click , the Large size icon

3 Use the mouse to begin erasing. You can select one pixel at a time, or you can drag the mouse.

Tip: When erasing the paint, it may be easier to magnify the size of the image using the magnification icons.

To resume painting, click , the Paintbrush icon.

To erase all paint on an image

1 Do one of the following as appropriate:

- Click , the Erase all paint icon, which removes all paint from the image.
- Click , the Undo last region paint icon, which allows you to undo the last paint stroke.

2 Click , the Default Mode icon, when you have finished painting the image.

Step 5, Commit

When you visualize a dataset in MIPAV, a composite of several layers appears in the default image window. The image layer contains the original image. The next two layers contain the results of applied utilities, algorithms, and paint. The fourth layer contains VOI contour information.

When you click the commit icons (, the Changes image where painted inside, icon and the , the Changes image where painted outside, icon), the paint and utility/algorithm layers are merged with the image layer and saved as a new file.

To commit changes, select one of the following commit icons:

- , the Changes image where painted inside, icon: This icon shows the image without the area you painted (Figure 214A).
- , the Changes image where painted outside, icon: This icon removes the painted area from the image and shows only the removed area (Figure 214B).

The software redraws the dataset with the intensity levels indicated on the image. You may need to adjust the lookup table (LUT) to see the image more clearly. Instructions for adjusting the LUT appear in Chapter 5, “Visualizing Images.”

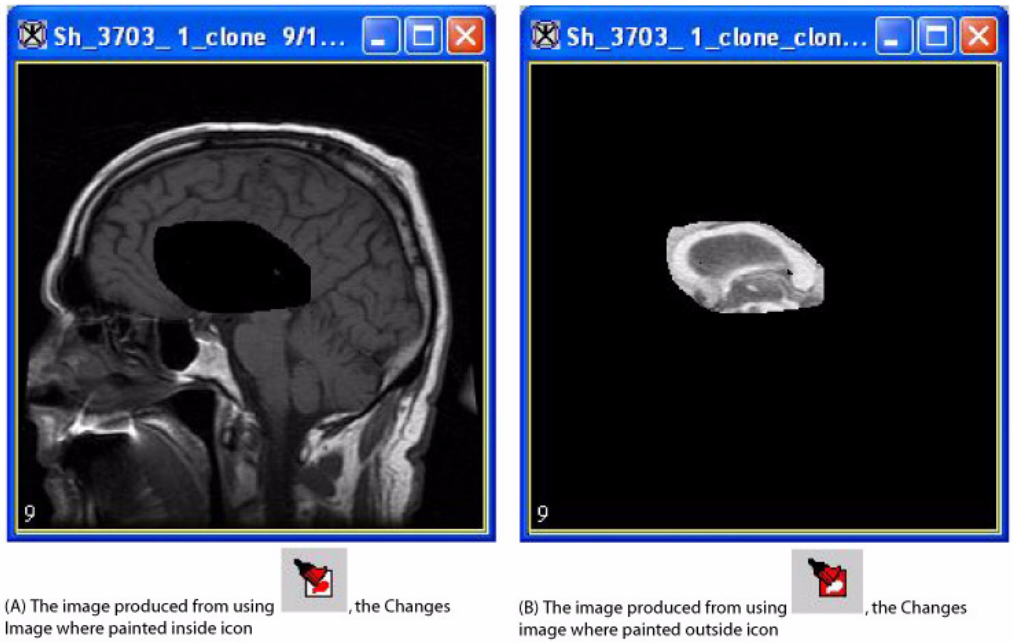


Figure 214. Images produced from using the commit icons

Creating a mask using the paint grow segmentation method

You can create a mask using the paint grow segmentation method, which uses voxel aggregation to group voxels into larger regions. You begin by selecting a voxel to serve as the *seed point,* or starting point. The software applies paint color to all voxels touching the seed point that fall within the intensity range that you specify.

Note: You cannot apply the paint grow segmentation method to RGB images.

To create a mask using the Paint Grow button

1. Click , the Paint Grow button. The Paint Grow dialog box appears (Figure 215).
2. Select the seed point, which is used as a starting point for the paint grow operation. To do this, move the pointer to the image. As you move the cursor, the location and intensity of the voxel under the pointer tip appears in the Cursor position and voxel intensity text box. Click the voxel you want to designate as the seed point.
3. Adjust the delta values and parameters.
4. Click Apply when complete to begin the paint grow method. The Paint Grow dialog box closes.

Cursor position and voxel intensity	Indicates the coordinates and intensity of the pixel under the mouse pointer tip. This pixel is the seed point.
Delta above selected voxel intensity	Once a seed point has been selected, MIPAV uses this value to determine whether to fill adjacent voxels with color. The voxels that are filled must have intensity levels that fall within the range of the seed point intensity minus the lower delta value and the upper delta value. For example, if seed point has an intensity of 100.0, and the *Delta Above Selected Pixel Intensity* value is 10 and the *Delta Below Selected Pixel Intensity* value is 15, MIPAV color-fills adjacent voxels whose intensities range from 85.0 to 110.0.
Delta below selected voxel intensity	Once a seed point is, MIPAV uses this value to determine whether to fill adjacent voxels with color. The voxels that are filled must have intensity levels that fall within the range of the seed point intensity minus the lower delta value and the upper delta value.

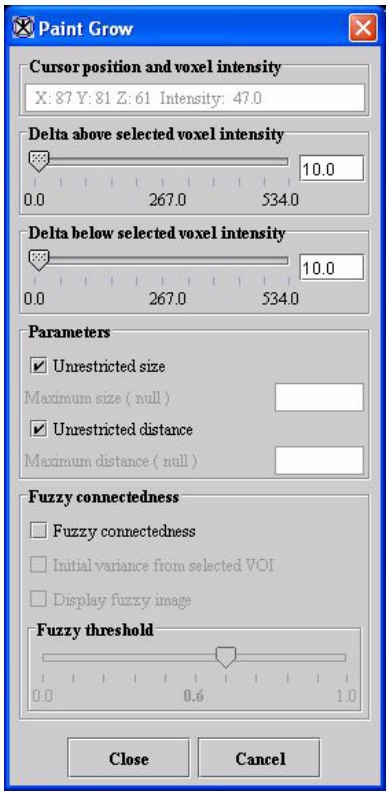


Figure 215. Paint Grow dialog box

Parameters	Constrains the growth of the paint grow operation. Select the unrestricted size and unrestricted distance check boxes to allow the paint grow operation to be applied without restraint. If the Unrestricted size check box is not selected, type the maximum size (in cubic meters) of the paint grow region in the text box. If the Unrestricted Distance check box is not selected, type the maximum distance from the original seed point in the text box.
Unrestricted size	TBD
Maximum size	TBD
Unrestricted distance	TBD
Maximum distance	TBD
Fuzzy connectedness	TBD
Initial variance from selected VOI	TBD
Display fuzzy image	TBD
Fuzzy threshold	TBD
Close	Closes this dialog box.
Cancel	Disregards any changes that you made in this dialog box and closes the dialog box.
Help	Displays online help for this dialog box.

Figure 215. Paint Grow dialog box (continued)

To correct the mask

If the results are not what you want, do the following:

1. Click , the Paint Grow button. The Paint Grow dialog box appears (Figure 215).
2. Select the seed point, which is used as a starting point for the paint grow operation. To do this, move the pointer to the image. As you move the cursor, the location and intensity of the voxel under the pointer tip appears in the Cursor position and voxel intensity text box. Click the voxel you want to designate as the seed point.

3 Adjust the delta values and parameters.

4 Click Apply when complete to begin the paint grow method. The Paint Grow dialog box closes.

If the results are not what you want, do either of the following:

- Click , the Undo last region paint icon, and start again.
- Click , the Erase icon, or click , the Erase all paint icon, to erase all paint.

5 Click one of the following commit buttons:

- , the Changes image where painted inside, icon: This icon shows the image without the area you painted (Figure 214A).
- , the Changes image where painted outside, icon: This icon removes the painted area from the image and shows only the removed area (Figure 214B).

Converting VOI contours to masks

You can convert a contoured VOI to a binary, short, or paint mask using the options found in the VOI menu in the MIPAV window.

To convert a contoured VOI to a binary mask

In a binary mask, the value 1 is assigned to the area inside the VOI; 0 is assigned to the area outside the VOI. Thus, typically, the area that represents the VOI is white, while the area outside the VOI is black.

1 Select VOI > Mask > VOI(s) to Binary Mask. The binary mask appears in a separate image window.

2 Save the image (optional).

To convert a contoured VOI to a short mask

In a short mask, the values 1 to 65,535 are assigned to the area inside the VOI; 0 is assigned to the area outside the VOI. Thus, typically, the area that represents the VOI is several shades of gray and the area outside is black.

1. Select VOI > Mask > VOI(s) to short mask option. The short mask appears in a separate image window.
2. Save the image (optional).

To convert a contoured VOI to a paint mask

1. Contour the VOI. For instructions on how to contour VOIs, refer to "Using contours to segment a VOI" on page 277.
2. Select the color, opacity, and intensity level of the paint.
3. Select VOI > Mask > VOI(s) to Paint Mask. The contours are filled with the default paint color.
4. Delete the contours by right-clicking the VOI and selecting Edit > Delete.
5. Save the image (optional).

Converting masks to VOI contours

To convert a mask to an image with VOIs

1. Create a paint mask. For information on how to do this, refer to "Generating masks" on page 299.
2. Select the VOI > Mask-> VOI.

   Contours replace the painted areas.