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3-D Image Processing Algorithms

Lab exercises in EIKONA 3D

Chapter 1

Basics

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Exercise 1.1: Opening and Saving a Volume

In this exercise we will see how we can use EIKONA3D to open and display a volume (3D image) and how we can save a volume from memory to disk.

Volume data are stored (with the exception of Raw Volume format that will be presented below) as a sequence of image files, one file per frame. EIKONA3D supports the following formats: TIFF Image Sequences, BMP Image Sequences, Targa Image Sequences, GIF Image Sequences, JPEG Image Sequences, PBM Image Sequences, PGM Image Sequences, PPM Image Sequences, Raw Image Sequences and Raw Volumes. The image filenames are of the form [base][index].[extension]. The base and extension parts of the filename are common to all files of the image sequence. The frame index is unique for each frame. Consecutive frame indices should be used (e.g. head0.tif, head1.tif, head2.tif, … head127.tif).

1.1.1. Open Volume

Let us suppose that a series of 128 TIFF grayscale images (filenames: head0.tif, head1.tif, head2.tif, … head127.tif) that form the 3-D image of an MRI scanned human head are stored in the directory `Eikona3D`. The volume can be loaded as follows:

- Choose the "**File→Open**" menu option. The "*Open*" dialog box appears on the screen (Fig 1).
- Specify the directory where the files reside (in our case `Eikona3D`) in the *Look in* field.
- Select the file format (in our case TIFF image sequence) in the *Files of type* field. At this stage, a list of all image files of the chosen format that reside in the selected directory appear in the dialog box. The user now has to enter the data required for loading the files:
  - ➢ *File Name Base, Channel 1 Extension*: the base and extension of the image filenames.
  - ➢ *Lower Frame Index*, *Upper Frame Index*: the first and the last frame indices of the image sequence to be loaded.
  - ➢ *Frame Index Length:* this field determines the index format; a value of zero means that there are no leading zeros in the index (e.g. base0.ext, base1.ext, …, base10.ext, …, base100.ext, …), whereas a non-zero value specifies a fixed length index (e.g. a value equal to 2 should be used in order to load the sequence base00.ext, base01.ext, …, base99.ext).

EIKONA3D provides a useful feature to automate the parameter selection procedure. By clicking on one of the files that belong to the image sequence that is to be opened, EIKONA3D retrieves all information required for loading the sequence. In our case, by clicking on one of the TIFF files that appear on the dialog box the following parameters are assigned automatically their appropriate values:

- ➢ *File Name Base: head*
- ➢ *Channel 1 Extension: tif*
- ➢ *Lower Frame Index: 0*
- ➢ *Upper Frame Index: 127*
- ➢ *Frame Index Length: 0*

However, one can override the automatically assigned values. For example, if only a subset of an image sequence need to be loaded, one can modify the *Lower/Upper Frame Index* values.

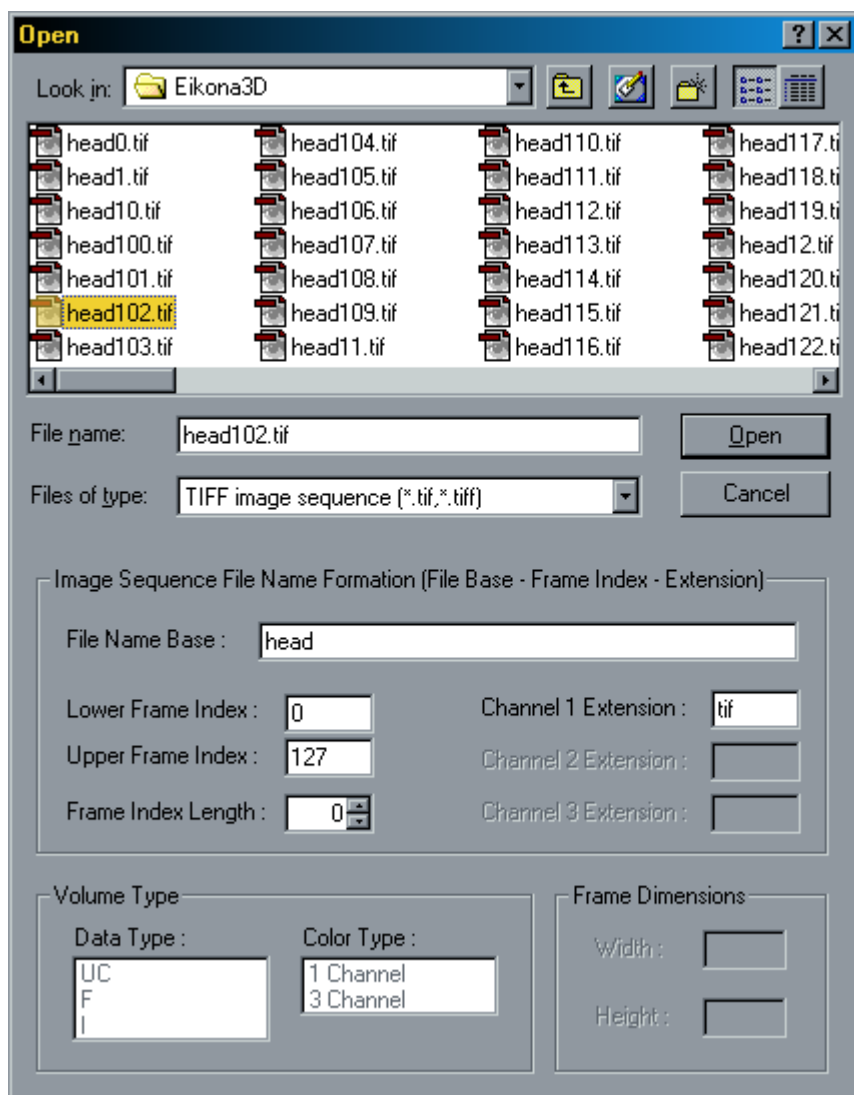- To end the input selection procedure one should click on the "*Open*" button.

Figure 1: An example of opening an image sequence in TIFF format.

The same procedure can be used to specify the loading parameters for all supported formats. However, there are two file formats that require a slightly different handling: Raw Image Sequence and Raw Volume.

In the case of a Raw Image Sequence one should manually specify the frame dimensions, whether a color or a grayscale image sequence is to be loaded and the format used to represent the data, i.e. fill in the *Data Type*, *Color Type* and *Frame Dimensions* fields:

- The *Data Type* field specifies the data type used for representing the voxel intensity or channel value. It can be assigned one of the following three values: *UC*=unsigned char, *F*=float, *I*=integer.
- The *Color Type* filed can be assigned either the value *1 Channel* for binary or grayscale volumes or the value *3 Channel* for color volumes (e.g. RGB, CMY, HIS, HSV, HLS).
- The *Frame Dimensions* (*width*, *height*) fields should be filled in with the number of rows and columns of each frame.

In the Raw Volume format, all frames are stored in a single file in a frame-row-column (z-y-x) manner. For loading such a volume the *File name*, *Data Type*, *Color Type*, *Lower* and *Upper Frame Index* and *Dimensions* (*width*, *height*) fields should be filled in.

- Upon completion of the input selection procedure the "*Select Volume*" dialog box (Fig. 2) appears on screen and the user selects the volume where the 3-D image is to be placed. Volumes are referred to by numbers 0, 1, 2 etc. A 3-D image that is loaded from disk can be placed either on an existing volume structure or in a new volume. For loading the data in a new volume the following steps should be taken:
  - Click on New[0] in the *Volumes* field.
  - Add a short description of the volume in the *Information* field (optional). At this stage the *Data Type*, *Color Type*, *Image Dimensions* and *Number of Frames* of the volume appear in this dialog box.
  - Click on the "OK" button.

Upon completion of the above procedure, the image sequence is loaded and the volume is automatically displayed on screen. This can be seen in Figure 3.
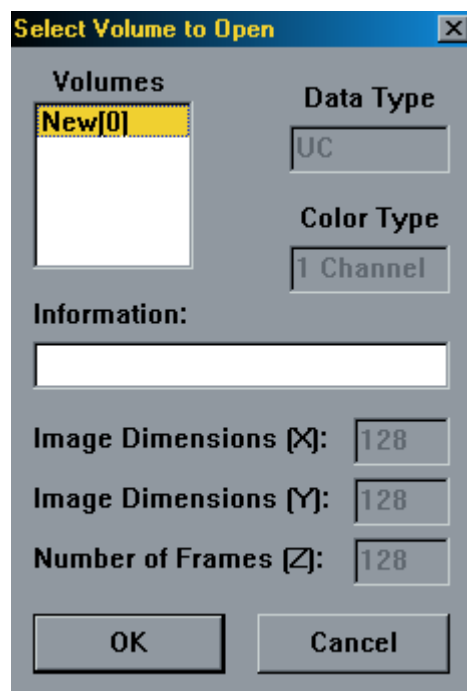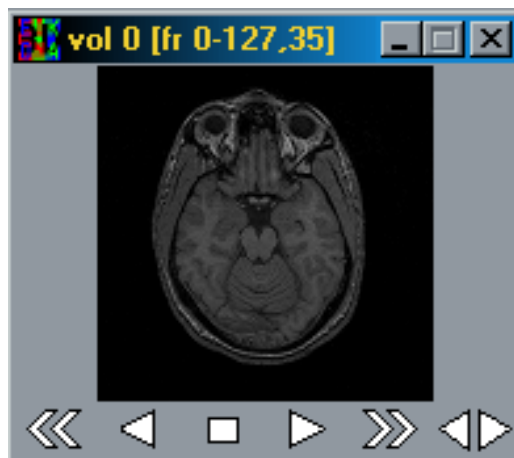

Figure 2: The Select Volume dialog box.

Figure 3: The 35th frame of the 'head' image sequence.

The user can view the frames comprising the volume as an image sequence. This can be accomplished using the buttons on the display window (forward one frame, forward playback, stop, backward playback, backward one frame, continuous loop playback). This window can be displayed for any existing volume by using the menu options **Visualization→BW Display** or **Visualization→Color Display.**

1.1.2. Save Volume

Let us suppose that the 'head' 3-D image is stored in volume 0. The volume can be written to disk as follows:

- Choose the "**File→Save**" menu option. The "*Select volume to Save*" dialog box appears on the screen.
- Select the volume that will be saved among the existing volumes (e.g. volume 0) and click *OK.* The ``Save'' dialog box appears.
- Specify the folder where the files will be stored (e.g. 'Eikona3D') in the *Save in* field.
- Specify the file format, (e.g. TIFF image sequence) in the *Save as type* field.

Default values for the lower and upper frame that will be saved (in our case 0 and 127 respectively), the frame index length (e.g. 0) and the filename extension (tif) appear on the dialog box. The user can change these values at will. Note that for color Raw Image Sequences an extension for each channel filename should be specified. Furthermore, the user selects the base name of the sequence that will be saved. By clicking on the ``Save'' button, a dialog box that asks the user to specify (if needed) some format-specific options appears. These options are the following:

- ▪ <u>TIFF image sequence</u> The user should select the *compression type* (no compression, LZW, Pack Bits) and the *photometric image type* (Min White/Min Black for grayscale volumes, RGB for color volumes).

- ▪ <u>Targa image sequence</u> For color volumes, the user should specify the *image resolution* (16/24/32 bits/pixel).
- ▪ <u>JPEG image sequence</u> The user should specify *the image quality factor* (0…100) and for color volumes the *output image type* (whether the image should be saved in grayscale or color) and whether *color subsampling* should be used.
- ▪ <u>PBM image sequence</u> This format is intended for binary volumes. The user should select between Raw and ASCII *image types*.
- ▪ <u>PGM image sequence</u> This format is intended for grayscales volumes. The user should select between Raw and ASCII *image types*.
- ▪ <u>PPM image sequence</u> This format is intended for color volumes but it can also be used for grayscale volumes. The user should select between Raw and ASCII *image types*.

- • Click on the "Save" button.

Upon completion of the above procedure, the volume is saved to disk.

Exercise 1.2: Create Volume

Let us suppose that we want to create a new volume (e.g. volume 1) with certain data type, color type and dimensions, in order to use it as an output volume in one of our subsequent operations. We select the menu option "**File→Create Volume**". In the "*Select Volume to Create*" dialog box that appears (Figure 4), we select *Volume* 1 and we specify the *Data Type* (Unsigned Character, Float or Integer) and the *Color Type (1 or 3 Channels* i.e., grayscale or color)* of the volume. Then we fill the rest of the fields (*Image Dimensions* and *Number of Frames*). After completing the above, we press the "OK" button to perform the operation.
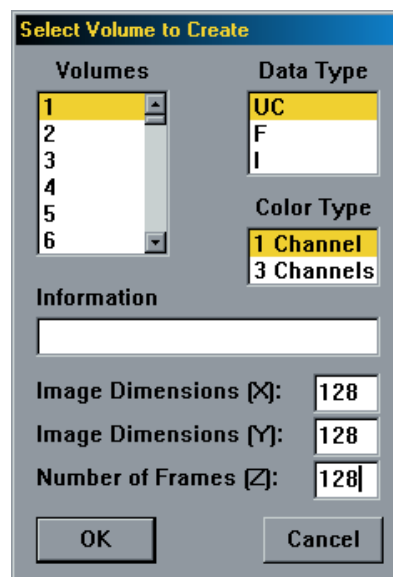

Figure 4: The Select Volume to Create dialog box.

Exercise 1.3: Display Coordinates

This is a toggle (on/off) option. If we want to display the coordinates window, we select the menu option "**File→Display Coordinates**". By repeating this selection the option is deactivated and the coordinates window disappears.

When the cursor is within a display window, its coordinates are displayed in the coordinates window, as shown in Figure 5. For grayscale volumes the grayscale value of the current voxel is displayed, while for color volumes the Red, Green and Blue channel values are displayed.
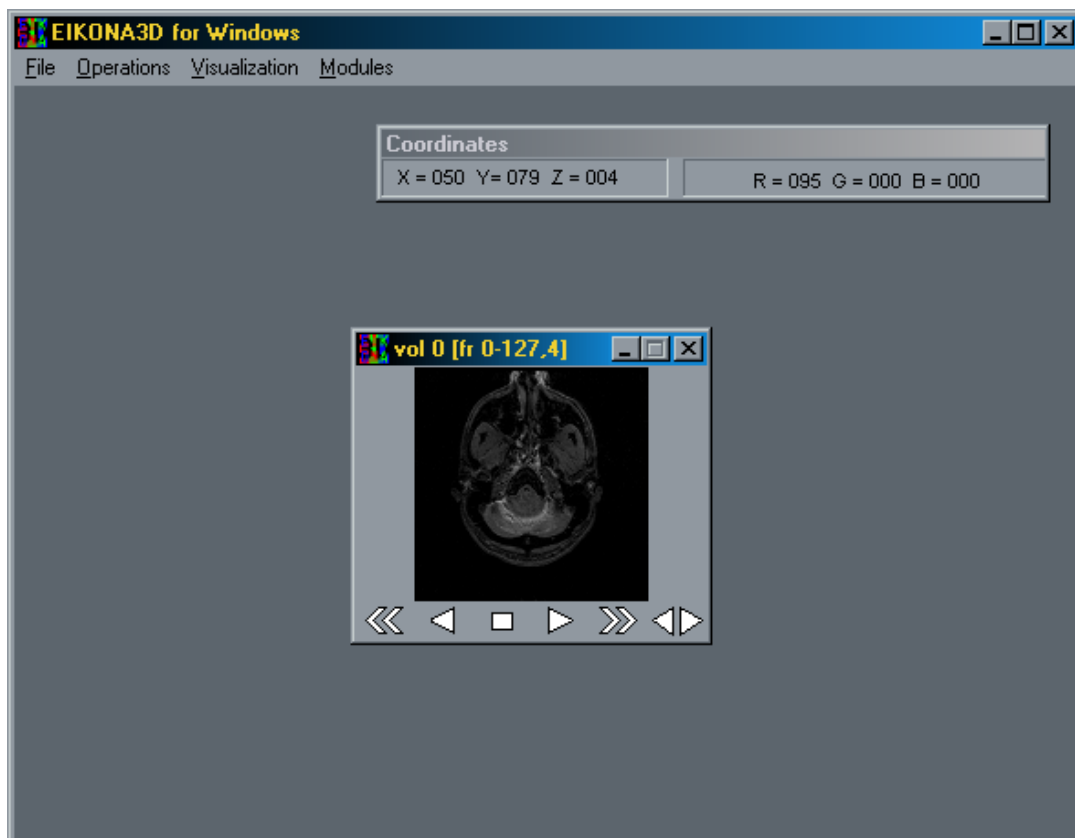
Figure 5: The Coordinates window.

Exercise 1.4: Pointwise binary operators

In this exercise, we use EIKONA3D to perform some pointwise operations between volumes. The operations that will be presented are the logical AND, logical OR and logical XOR. Logical operators are applied on binary volumes i.e. volumes whose voxel values are 0 and 255. In the following we will use two binary 3-D images in TIFF format (filenames cube_one0.tif… cube_one255.tif and cube_two0.tif… cube_two255.tif) that are provided along with this file. We will assume that the user has loaded these two 3-D images in volumes 0 and 1.

1.4.1. Logical AND

In order to perform the Logical AND operation we select the menu option "**Operations→Basic→Logical AND**".

- In the first "*Select Input Volume*" dialog box that appears (Figure 6a) we select *Volume* 0, and then click on the "OK" button.

- In the second "*Select Input Volume*" dialog box that appears we select *Volume* 1, and then click on the "OK" button.

- In the "*Select Output Volume*" dialog box that appears (Figure 6b) we select *Volume* New[2], and then click on the "OK" button.

If instead of a new output volume an existing volume is selected, its data type, color type, dimensions and information are displayed in the dialog box. At the end of the operation volume 2 contains the logical AND of volumes 0 and 1. The result of this operation can be seen in Figures 8-10.

Note that this operation as well as all other operations included in EIKONA3D can be applied to subparts of the volumes referred to as VOI (Volume Of Interest). In order to set the VOI in a volume, enable the tag *Change VOI* in the "*Select Input Volume*" dialog box (Figure 7) and provide the desired values in the fields *Low VOI* (minimum frame index), *Up VOI* (maximum frame index), *Left VOI* (minimum frame column index), *Right VOI* (maximum frame column index), *Top VOI* (minimum frame row index), *Bottom VOI* (maximum frame row index). The Left/Right and Top/Bottom VOI coordinates can be also set by clicking on the upper left VOI corner within the volume display window (Figure 3) and moving the mouse (keeping the button pressed) to the lower right corner of the VOI. A white rectangle appears on the display window to assist the user with the VOI selection procedure.
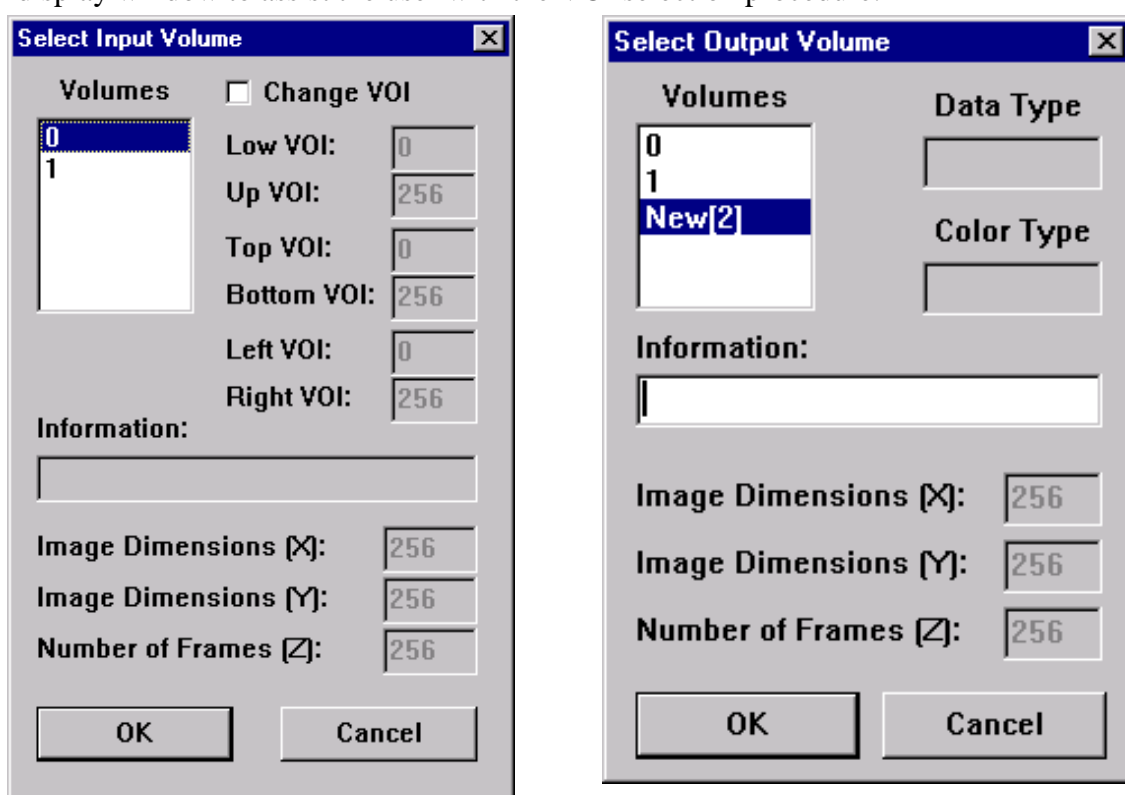
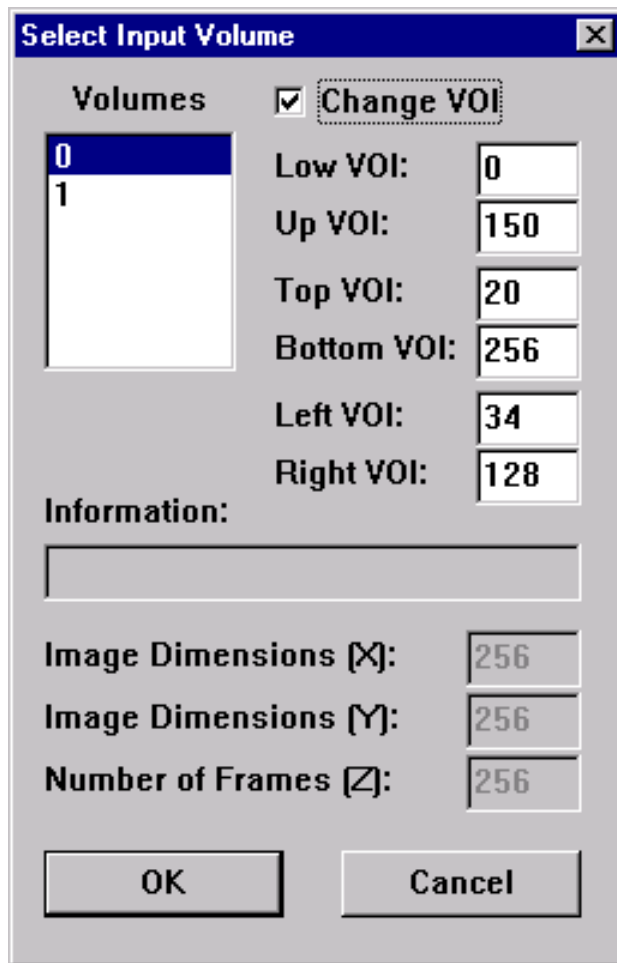**Figure 6 The Select Input Volume and Select Output Volume dialog boxes.**
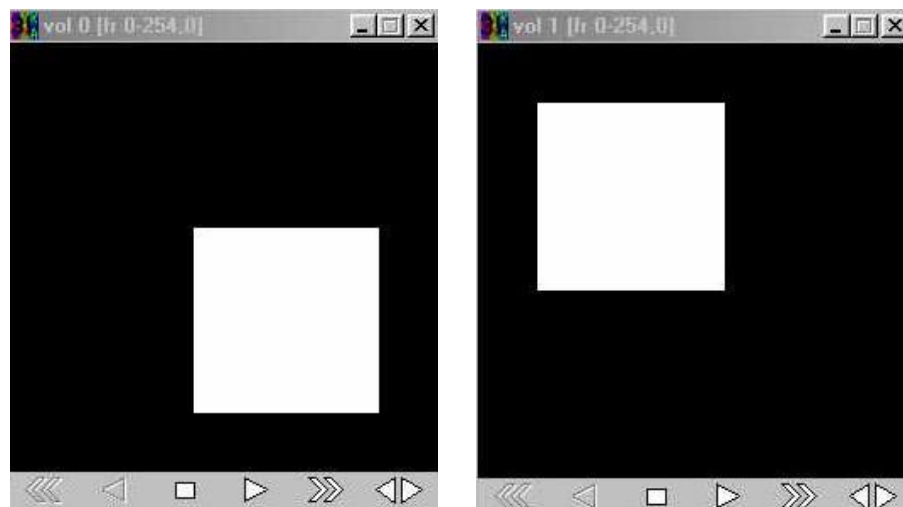
Figure 7 Changing the VOI of an operation.

Figure 8: Two frames of the binary input volumes cube_one and cube_two.
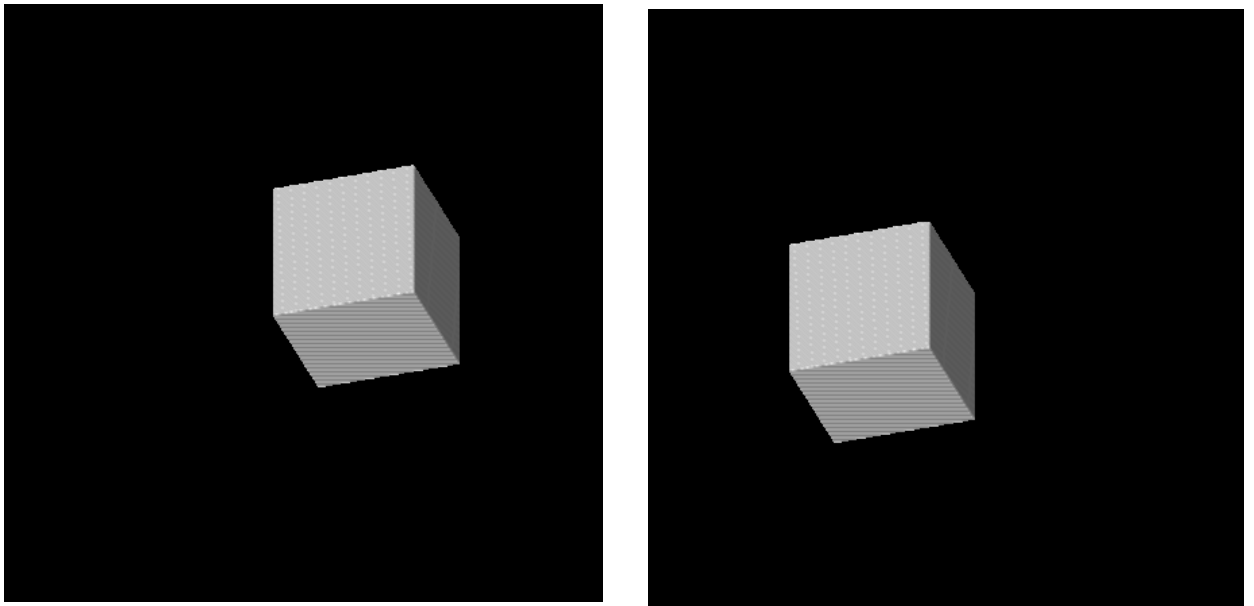
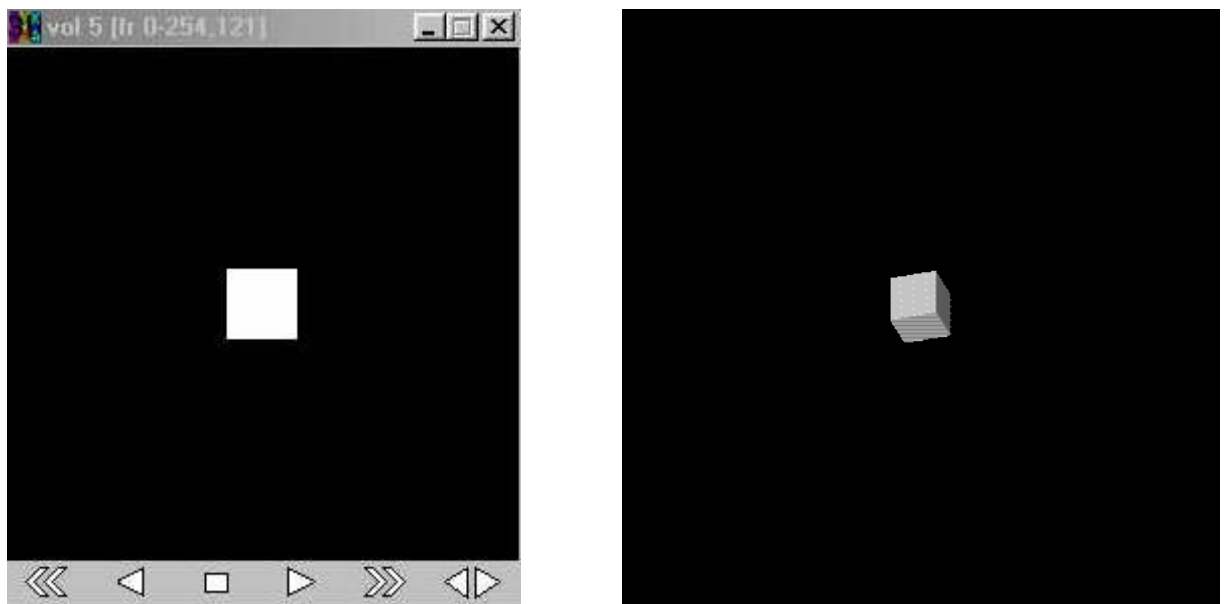**Figure 9: 3-D rendering of the binary volumes cube_one and cube_two.**

Figure 10 (a) A frame of the volume generated by evaluating the logical AND of the volumes depicted in Figures 8,9. (b) 3-D rendering of the same volume.

1.4.2. Logical OR and XOR

In order to perform the Logical OR and the logical XOR operations we should select the menu options "Operations→Basic→Logical OR" or "Operations→Basic→Logical XOR". The subsequent procedures are exactly the same with those described in the previous section. The results of these operations can be seen in Figures 11, 12.
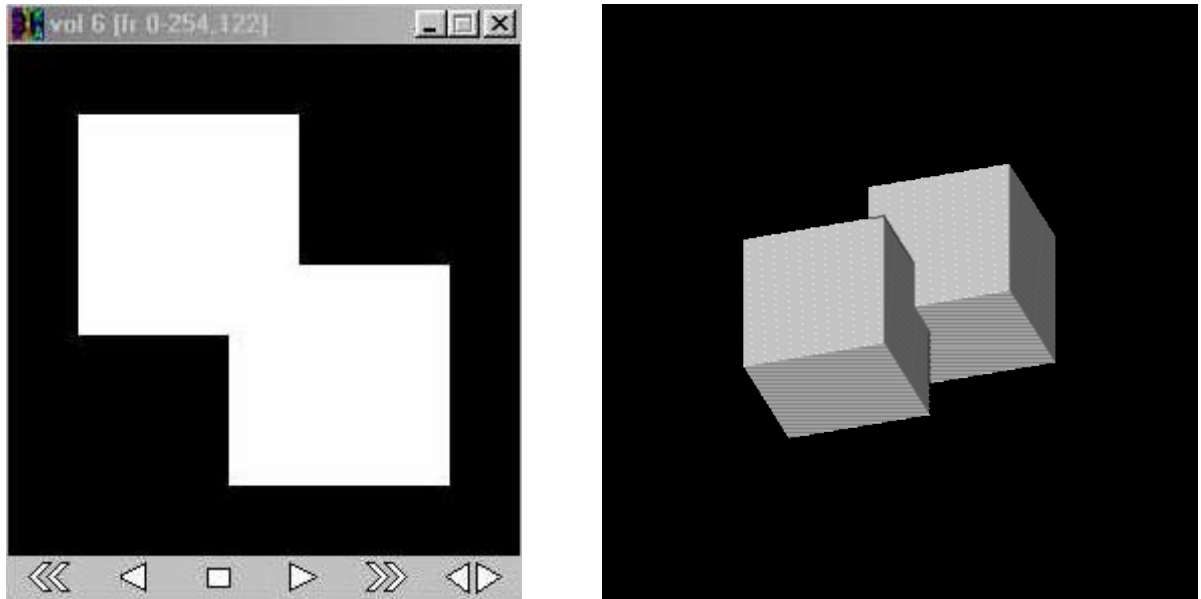
Figure 11: (a) A frame of the volume generated by evaluating the logical OR of the volumes depicted in Figures 8,9. (b) 3-D rendering of the same volume
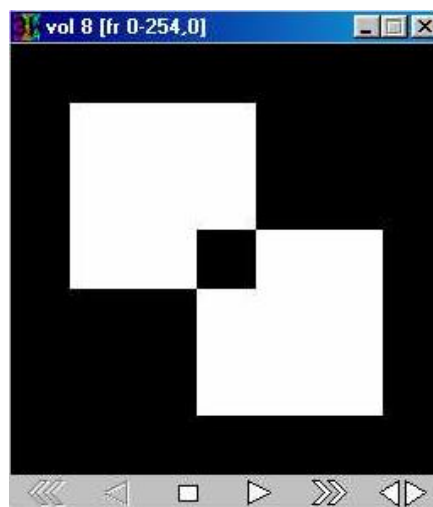
.

Figure 12: A frame of the output volume generated by evaluating the logical XOR of the volumes depicted in Figures 8,9.

Exercise 1.5: Frame Gallery

In section 1.1 we have seen how one can view the frames that make up a 3-D image using the Visualization→BW Display menu option. An alternative way to view these frames is by using the option Visualization→Frame Gallery that displays the frames of a volume as a gallery image, that is, an image depicting all frames simultaneously, one next to the other (usually in small size). The user selects the volume that will be

displayed using the *Select Input Volume* dialog box. Then he fills in the required parameters in the *Frame Gallery Display Options* dialog box. In particular, he enters the number of frames that will be displayed in one row of the gallery image (*Specify frames per row* edit box) and the interpolation method (nearest neighbor or linear) that will be used for resizing the frames in order to fit in the gallery window. The frame gallery display appears on the screen, each frame accompanied by its index number (Figure 13). If the user clicks with the left mouse button on a specific frame in the frame gallery, this frame becomes the current frame in any currently open display window of the corresponding volume.
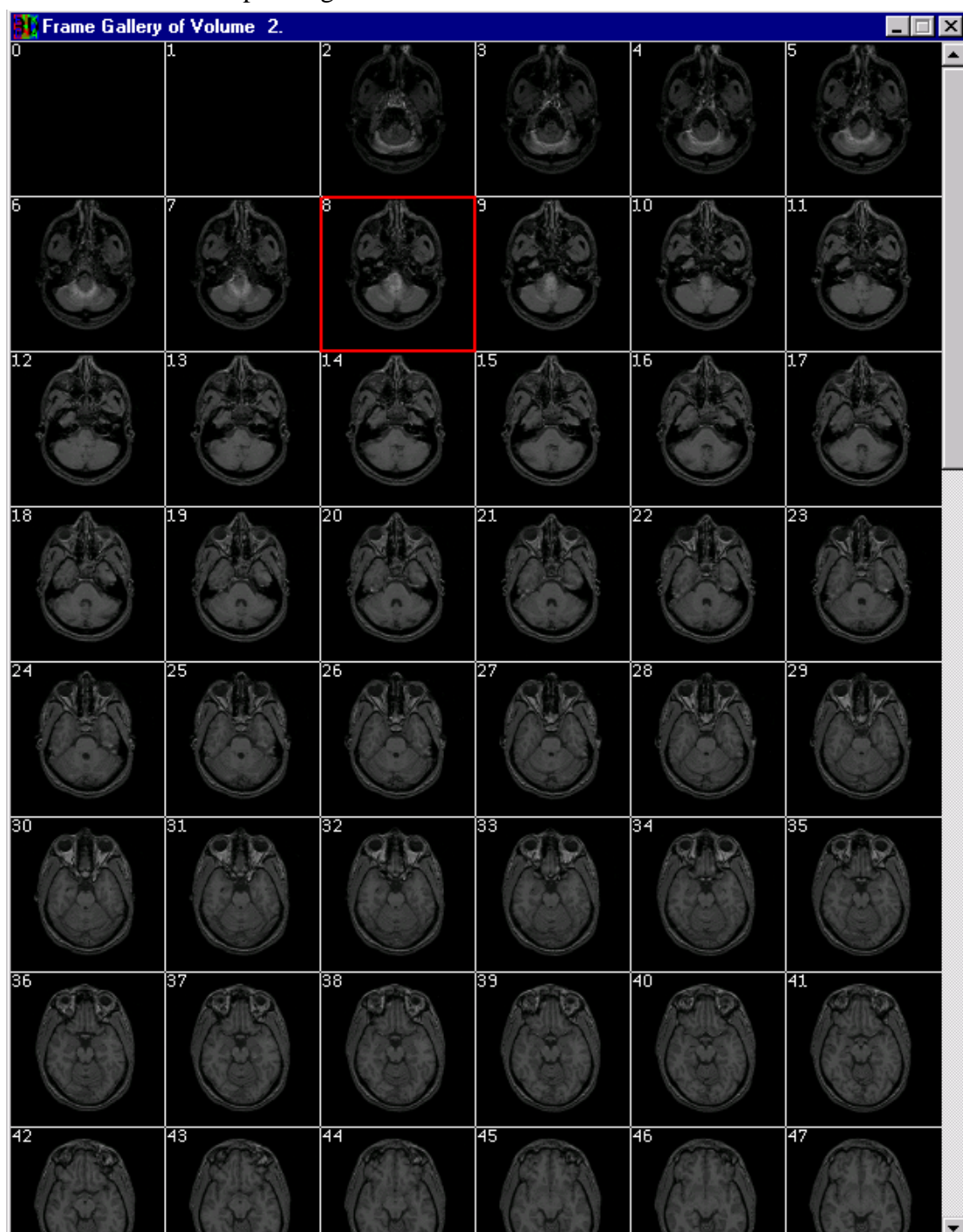

Figure 13: The frame gallery display of the 'head' volume.