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3-D Image Processing Algorithms

Lab exercises in EIKONA 3D

Chapter 7

Visualization

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The Volume Visualization module is the file VOLVIS.DLL. If this DLL exists in the same directory with the EIKONA3D executable, a submenu called **Volume Visualization** appears in the **Modules** menu. The options of this sub-menu provide several ways of 3D visualization of volumetric data. In this chapter we will see how we can use EIKONA3D for:

- Normal projection
- Average projection
- Maximum projection
- Sectioning
- Volume rendering

In order to exemplify the above operations, the 'head' volume will be used. We will assume that this volume has been loaded in volume 0.

Exercise 7.1: Normal Projection

Normal projection is a simple volume rendering technique. It casts rays from each image plane pixel and assigns to this pixel the grayscale/color value of the first object voxel intersected by the ray. In order to visualize the data using normal projection we choose **Modules→Volume Visualization→Normal Projection**. The *Select Volume to Render* dialog box appears on the screen, and we should select the input volume (volume 0).

Just after this stage two windows appear on the screen: the *Normal of Volume 0*, window that displays a full-size 3-D visualization of the selected volume and the *Volume Visualization Control* window that provides the means to control the visualization (Figure 1).

The control window displays a preview of the visualization along with the axes of an orthogonal coordinate system. The preview display works with a sub-sampled version of the input volume, thus allowing real time manipulation of the rendered data set. The user can use the mouse to rotate the 3-D display in the preview window, i.e., set the desired viewpoint defined by two angles: *theta* that controls the rotation around the z-axis and *phi* that controls the rotation around the x-axis. This can be accomplished by moving the mouse inside the preview window while keeping the left mouse button pressed. The angle *theta* can be changed by moving the mouse in the left-right direction, whereas the *phi* angle can be changed by moving the mouse in the up-down direction. Alternatively, the user can directly set the view angle values (in degrees) in the corresponding edit boxes. Furthermore, the user can use the control window to change the threshold values that define the maximum intensity/color value for the background voxels. Voxels with intensity/color value smaller than these thresholds are considered background voxels and their value is set to zero during the visualization procedure.

When the view angles and threshold values have been set, the user can refresh the full-size display window by clicking on the *Update* button. The 3-D view in the *Normal of Volume 0* display window can be saved to disk by selecting the *Save Projection* menu option from its system menu. The user can also generate a series of frames (movie) depicting a full rotation of the volume around the z-axis. Each frame represents a view of the volume calculated with successive increments of *theta* and the current *phi* value. In order to produce the movie the user selects the desired values for threshold and *phi* through the *Volume Visualization Control* window and then presses the *Movie* button. Then, a dialog box prompting the user to provide the number of frames for the movie appears (Figure 2). By selecting a big number of frames the user can generate successive views of the rotating volume with small increments of theta and thus achieve smooth transitions between frames. Obviously, the more frames desired, the longer it takes for the movie to be generated. Let us suppose that we choose the movie to consist of 10 frames. When pressing the *OK* button the *Select Output Volume* dialog box appears. Suppose that we choose a new volume (New[1]) for storing the movie sequence. Upon completion of this procedure the user can view the generated sequence using the controls (forward/backward playback, forward/backward one frame etc.) of the corresponding volume display window. The first three frames of the movie can be seen in Figure 3.

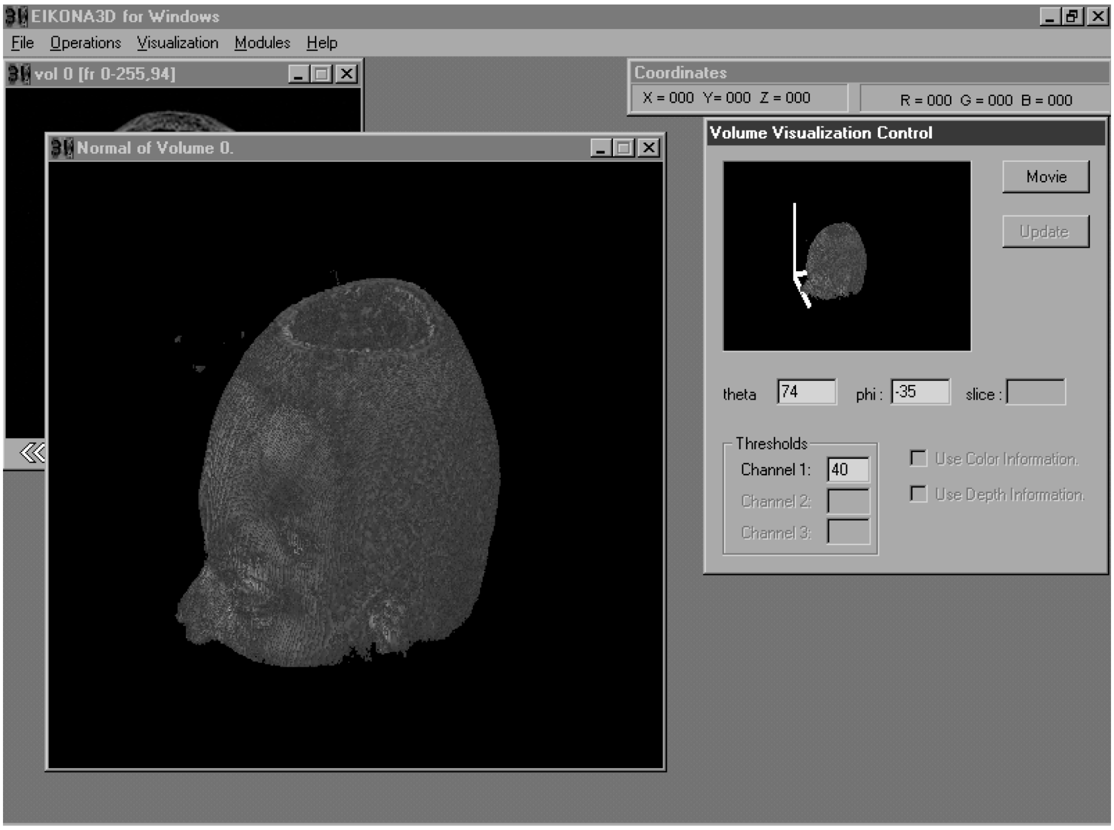


Figure 1: The Volume Visualization Control window and the rendering window of the Normal Projection operation.

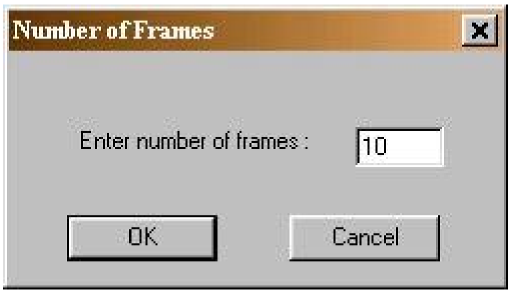
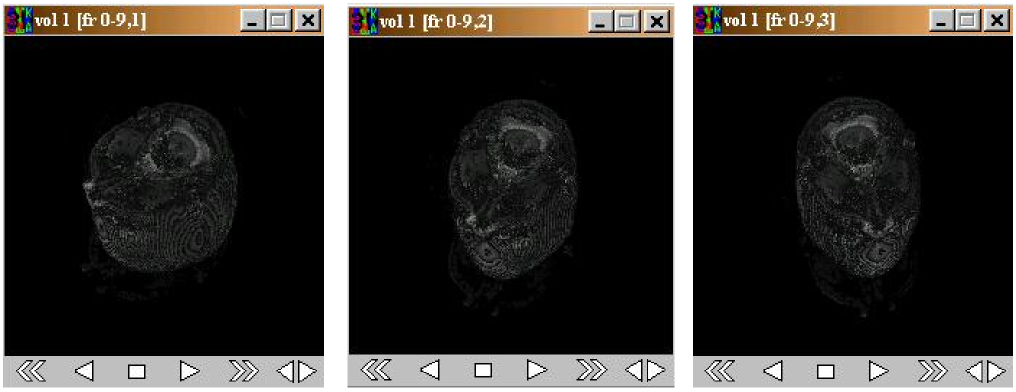


Figure 2: The Number of Frames dialog box.



(a) **(b)** **(c)**

(a) Figure 3: Three frames of a 10-frame sequence generated using the movie command on the normal projection of a volume.

Exercise 7.2: Average Projection

Average projection renders a volume by casting a ray from each image plane pixel and averaging voxel intensities along each ray. Average projection can be generated by selecting **Modules→Volume Visualization→Average Projection.** The procedure for generating and manipulating the average projection of a volume is identical with that described above for the normal projection, the only difference being that the threshold variable has no effect in this case. A movie depicting the rotating volume can be also generated. An example of average projection is shown in Figure 4.

Figure 4: Average projection of the 'head' 3-D image.

Exercise 7.3: Maximum Projection

Maximum projection renders a volume by casting a ray from each image pixel and calculating the maximum voxel intensity along each ray (Figure 5). In order to render a volume using maximum projection we choose **Modules→Volume Visualization→Maximum** and then follow the procedure described for the average projection.

Figure 5: A view of the maximum projection of the 'head' volume.

Exercise 7.4: Sectioning

This menu option performs volume slicing, i.e., it displays the intersection between the volume and a cutting plane, whose position and orientation is selected by the user. To perform sectioning we should select **Modules→Volume Visualization→Section**. Having selected the volume that will be displayed through the corresponding dialog box, the display window *Section of Volume 0* and the *Volume Visualization Control* window appear (Figure 6).

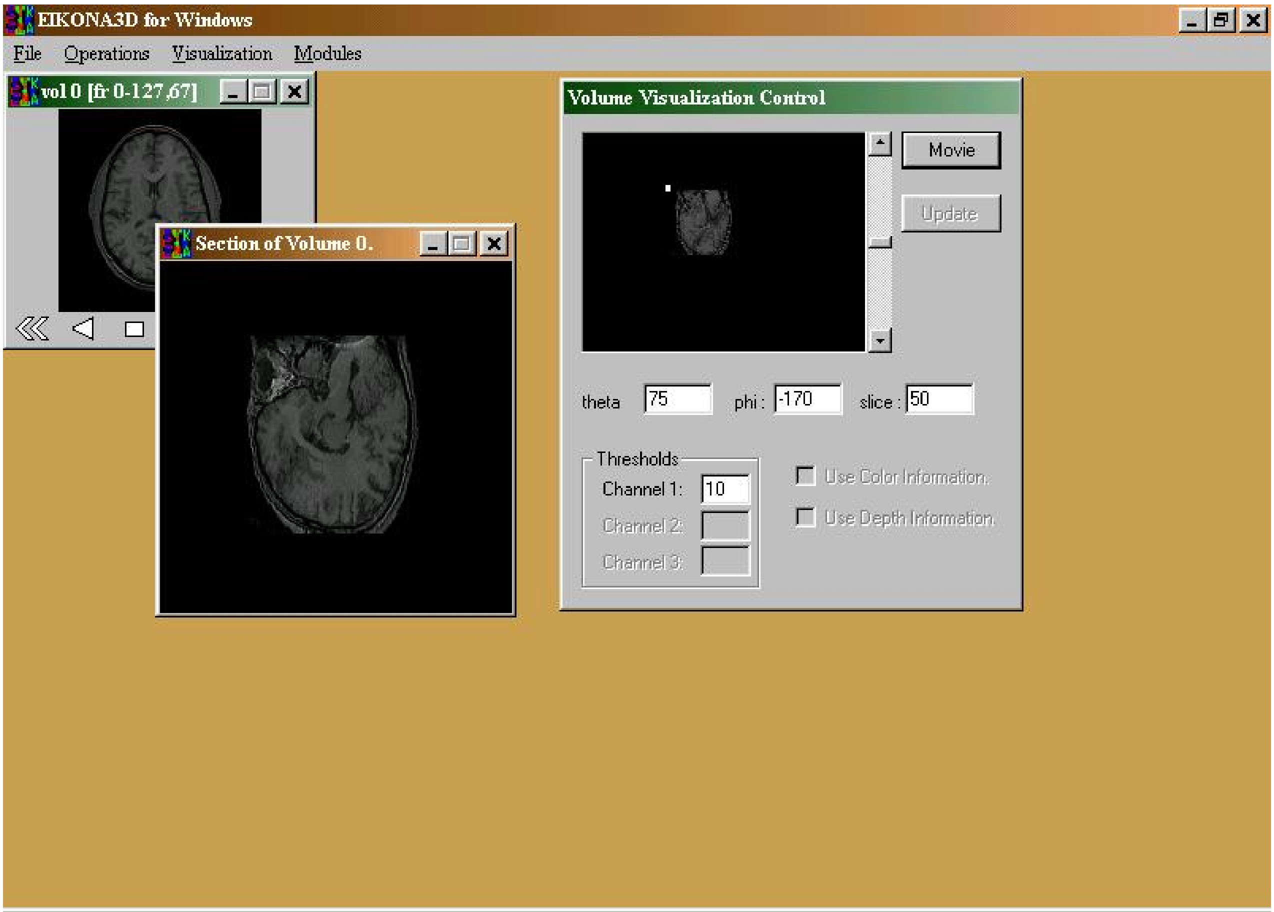


Figure 6: The Volume Visualization Control window and the rendering window of the sectioning operation.

The section image is computed by removing the part of the volume that is in front of the cutting plane. Instead of providing means to set the position and orientation of the cutting plane, the method keeps the cutting plane parallel to the screen and allows the user to rotate the volume in a way similar to that described in the previous sections, i.e. by controlling the theta and phi angles either by using the mouse or by setting their values explicitly in the corresponding edit boxes. The distance of the cutting plane from the viewer can be controlled by using the slide bar next to the preview window or by setting a value in the range 0…100 in the *slice* edit box. The threshold values have no effect in this operation.

In this example, we have set the *theta* angle to 75, the *phi* angle to –170, and the *slice* value to 50. When pressing the *Update* button the corresponding section appears in the display window (Figure 7).

Figure 7: An example of the sectioning operation.

A movie depicting the volume being sliced by moving the cutting plane parallel to the screen while keeping the volume in a fixed position (fixed phi and theta angles) can be also produced in this case.

Exercise 7.5: Volume Rendering

In the so-called Volume Rendering option the intensity of the pixels in the 3-D view is calculated by taking into account the angle between the object surface normal and the viewing direction. The user can also choose to incorporate depth information in the rendering procedure. In this case the pixel intensity in the projected image is inversely proportional to the distance of the object point from the viewer. Furthermore, information on the grayscale/color value of the object can be integrated in the rendering procedure.

This type of rendering can be generated by selecting the menu option **Modules→Volume Visualization→Volume Rendering** and following the procedure described in the section dealing with the normal projection method. The user can set the visualization options using the *Volume Visualization Control* window which, in addition to the volume preview window and the *thresholds*, *theta* and *phi* edit boxes, contains two check boxes that affect the rendering: *Use Depth Information* and *Use Color Information.* When none of those options is selected, the rendering takes into account only the angle between the surface normal and the viewing direction (Figure 8)

The *Use Depth Information* option, is a toggle option. When enabled, the rendering takes into account the depth of the rendered object surface. Surface points that are at a greater distance from the viewing plane appear darker (Figure 9).

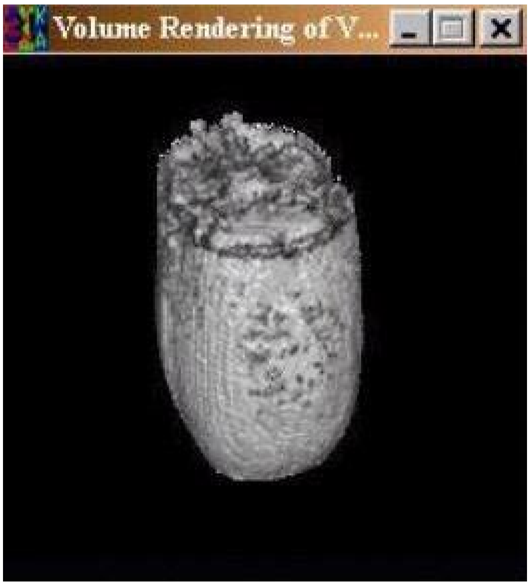


Figure 8: A view of the volume rendered 'head' 3-D mage.

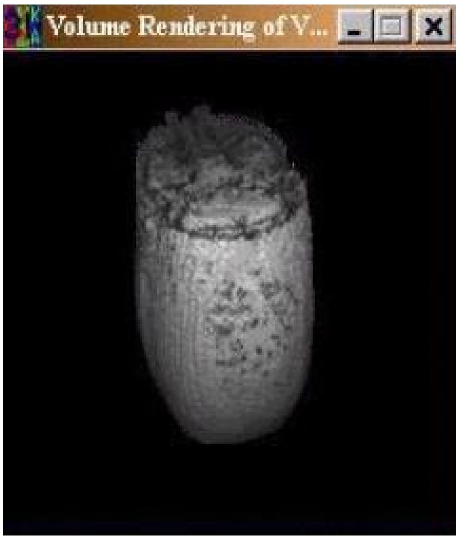


Figure 9: An example of using the *Use Depth Information* option in volume rendering.

The *Use Color Information* is also a toggle option. When enabled, the rendering takes into account the grayscale/color of the rendered object surface (Figure 10).

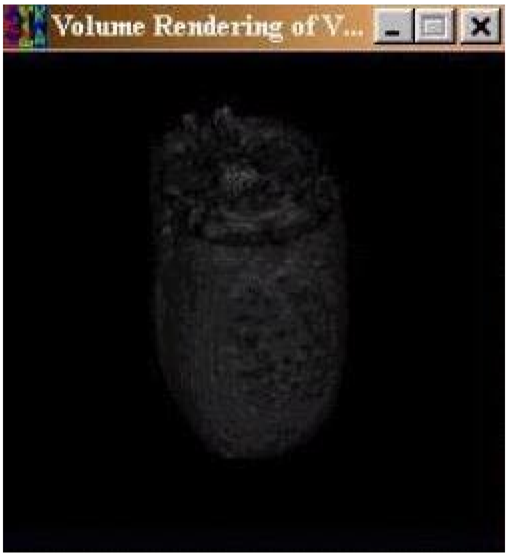


Figure 10: An example of using the *Use Color Information* option in volume rendering.