

# Marching Cubes Module

## 1. Introduction

Marching Cubes is an algorithm that transforms volumetric 3D object representation to 3D surface representation [1]. The 3D surface is represented in a triangular form. The Marching Cubes module initially reads the volumetric data the user has provided and creates a surface model of a 3D object. The user has the ability to save the surface model in various file formats as well as to directly show it on screen.

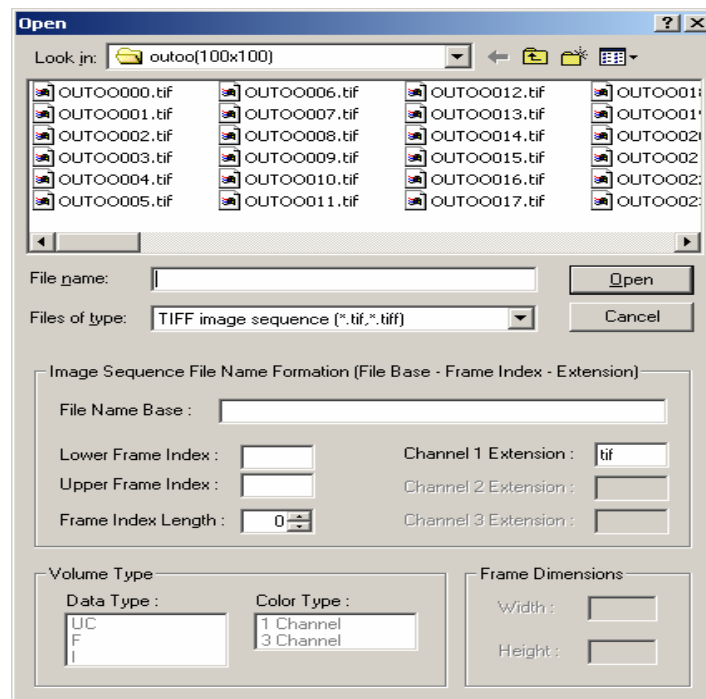


Figure 1: The *Open* dialog box.

Marching Cubes is a single document interface (SDI) Windows (Win32 architecture) application. It is totally coded in C++ programming language. All operations are executed through menu commands and dialogs which extend the user-friendliness of the EIKONA3D software. Each 3D model is displayed in an OpenGL platform inside the EIKONA3D workspace. The module comes in a single DLL (Dynamic Link Library) file called `marching_cubes.dll`. In order to install the module you only have to copy the file in the installation directory of EIKONA3D (where the `eikona3d.exe` file resides in) and restart EIKONA3D to recognize the new module. After launching the EIKONA3D package, the Marching Cubes module will create a new submenu under the name *Marching Cubes*. By choosing *File>Open*

from EIKONA3D main menu you can load a 3D object volume, i.e. volumetric data (serial object slices) to application's workspace from a file in disk.

Executing *Open* command will show up the file open dialog (Figure 1) from which navigation to the file system and selection of the desired volumetric data can be performed. The user has to choose one of the serially assigned slices (whichever) for the volumetric data to be loaded.

The *Marching Cubes* command under the *Modules* menu executes the Marching Cubes algorithm on the volumetric data the user has loaded. This command causes the execution of the Open Volume dialog (Figure 2) in which the user chooses the volume to be triangulated.

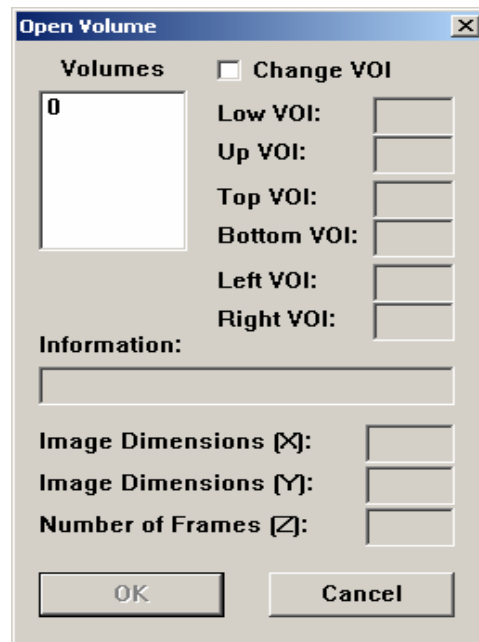


Figure 2: The *Open Volume* dialog box.

## 2. Marching Cubes Procedures dialog

*Options for 3D Model* tab: The Model dialog supplies the Marching Cubes Options for the 3D model (Figure 3).

*Distance between slices* text field: It represents the distance between the slices in the Z axis. Its value must vary from 1 to 50 voxels, otherwise an error message is displayed.

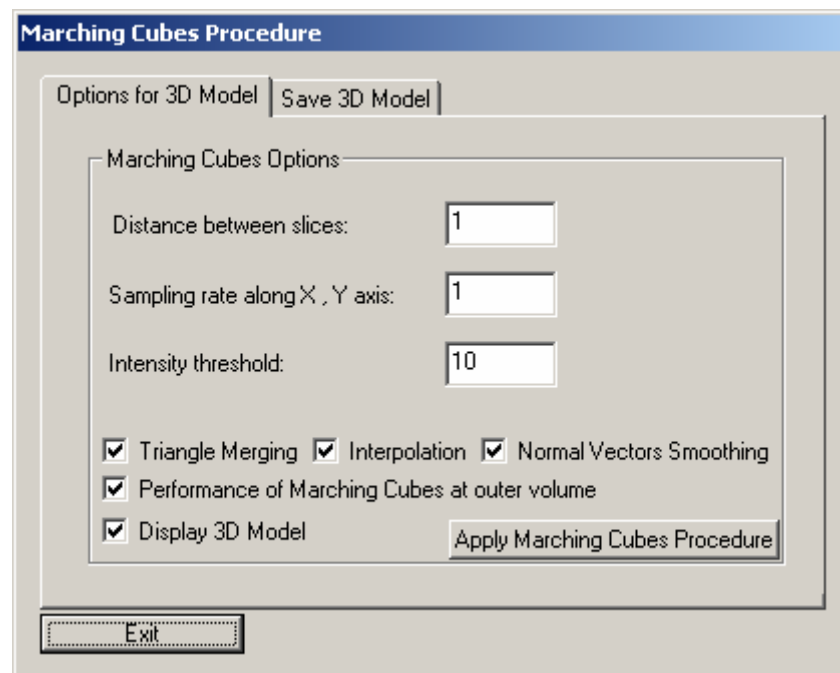


Figure 3: The *Options for 3D Model* dialog box tab.

*Sampling Rate along X,Y axis* text field: It represents the sampling rate of the pixels to be followed in order to create the new reduced in dimension slices from the original ones. Its value must vary from 1 to 20, otherwise an error message is displayed.

*Intensity threshold*: It represents the threshold according to which voxels that have intensity greater than or equal to that value are the ones that compose the 3D object, while the rest are background voxels. Its value must vary from 1 (black) to 255 (totally white), otherwise an error message is displayed.

*Triangle Merging* check box: If checked, the algorithm merges all coplanar triangles into larger polygons, so that the triangle number is reduced. No vertex coordinates are computed here. If not checked, the coplanar triangles are not merged.

*Interpolation* check box: If checked, the algorithm calculates the vertex locations by linear interpolation of local cube vertices. The corresponding normals are also computed here. If not checked, the mean of each local cube is taken into consideration for the calculation of the triangle vertex coordinates.

*Normal Vector Smoothing* check box: If checked, the algorithm calculates the normals for each vertex, estimates their arithmetic mean value and assigns it to that vertex. If not checked, no normal vector smoothing is applied.

*Extraction of exterior surface only* check box: If checked, the algorithm produces only the exterior object surface (i.e. it does not describe object holes).

*Show 3D model* button: When checked, an OpenGL platform is opened, where the 3D model is displayed (Figure 4).

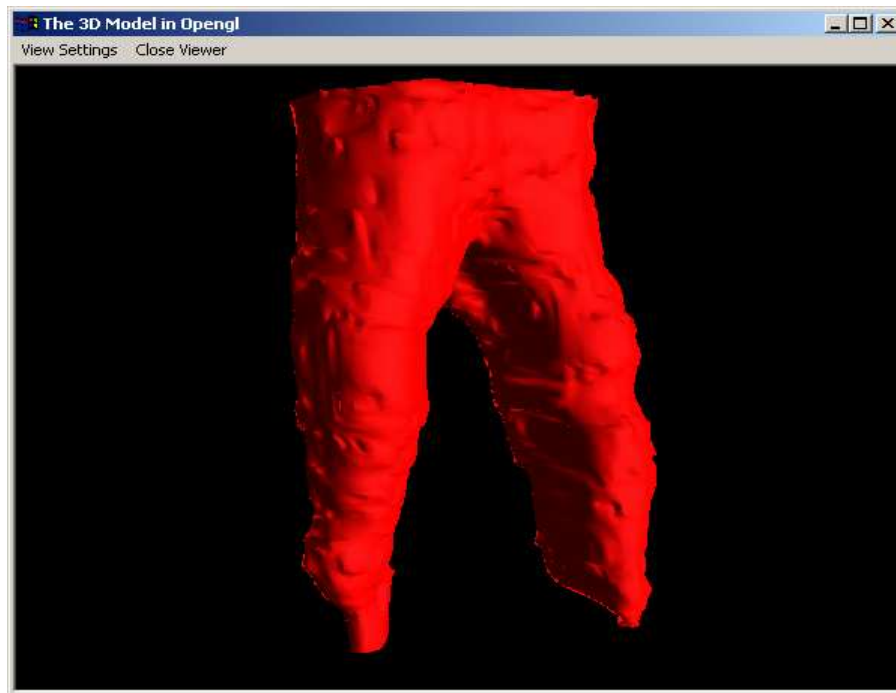


Figure 4: The 3D model in OpenGL display window.

If the *Apply Marching Cubes* button has not been selected previously, an error message is displayed.

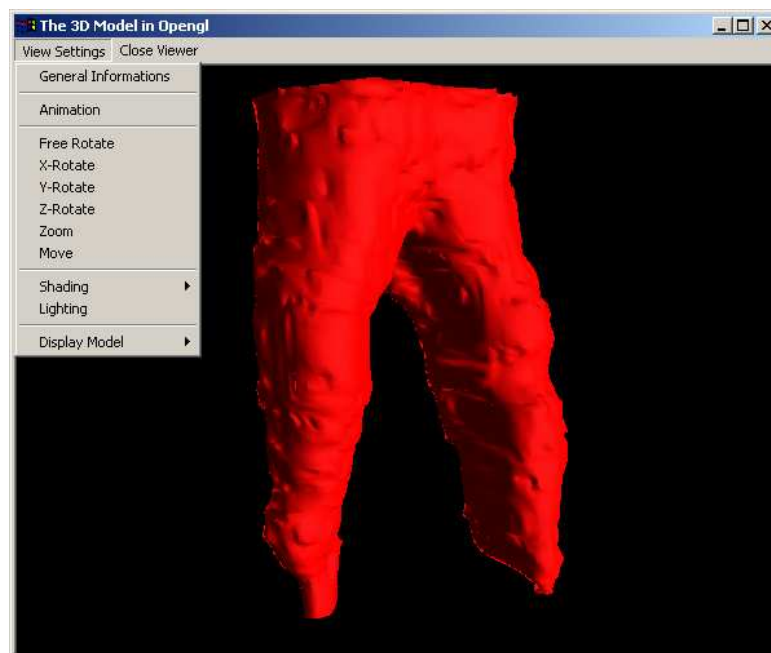


Figure 5: The *View Settings* menu.

The *View settings* menu (Figure 5) contains useful commands for manipulating the 3D model. Each command of the menu is described in details below.

*General Informations* command: It opens the *Informations* dialog (Figure 6).

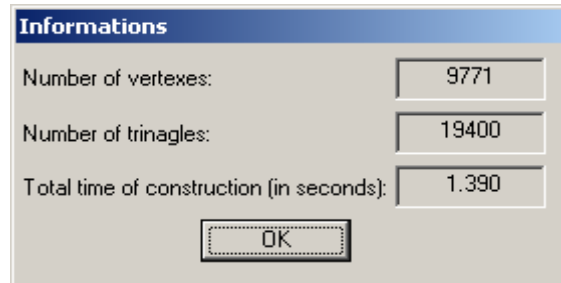


Figure 6: The *Informations* dialog box.

In this dialog the number of vertices, the number of triangles and the total calculation time (in seconds) of the 3D surface model are given.

*OpenGL Animation* command: It opens an animation settings dialog (Figure 7).

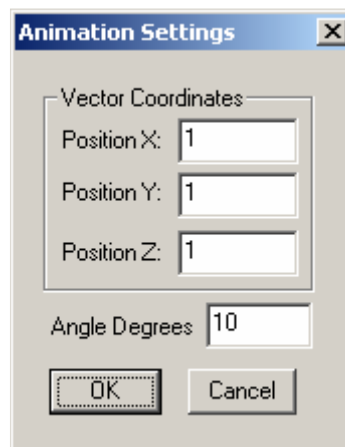


Figure 7: Animation Settings.

Its fields are:

*Vector Coordinates* panel:

*Position X* : It represents the X coordinate of the vertex around which the 3D model is to be rotated.

*Position Y*: It represents the Y coordinate of the vertex around which the 3D model is to be rotated.

*Position Z*: It represents the Z coordinate of the vertex around which the 3D model is to be rotated.

For all of the above coordinates, their values must not be zero concurrently. Otherwise, an error message is displayed.

*Angle degrees*: It represent the degrees around which the vector is to be rotated. Its value must vary from 1 to 359 degrees. Otherwise, an error message is displayed.

*Free Rotate* command: It allows the user to freely rotate the 3D surface model using the mouse.

*X-Rotate* command: It allows the user to rotate the 3D model along the X axis using the mouse.

*Y-Rotate* command: It allows the user to rotate the 3D model along the Y axis using the mouse.

*Z-Rotate* command: It allows the user to rotate the 3D model along the Z axis using the mouse.

*Zoom* command: it allows the user to zoom in moving the mouse to the upper side of the window and to zoom out moving the mouse to the opposite side of the window.

*Move* command: Allows the user to translate the model using the mouse.

*Shading* submenu:

*Flat* command: No smoothing of the triangles is applied.

*Smooth* tab: Smoothing of the triangles is applied. The smoothing procedure is applied by default.

*Lighting* menu command: It enables/disables the lighting of the 3D model. The default choice is the enabled lighting.

*Display Model* submenu:

*Solid* command: It displays polygon filled with texture (Figure 8).

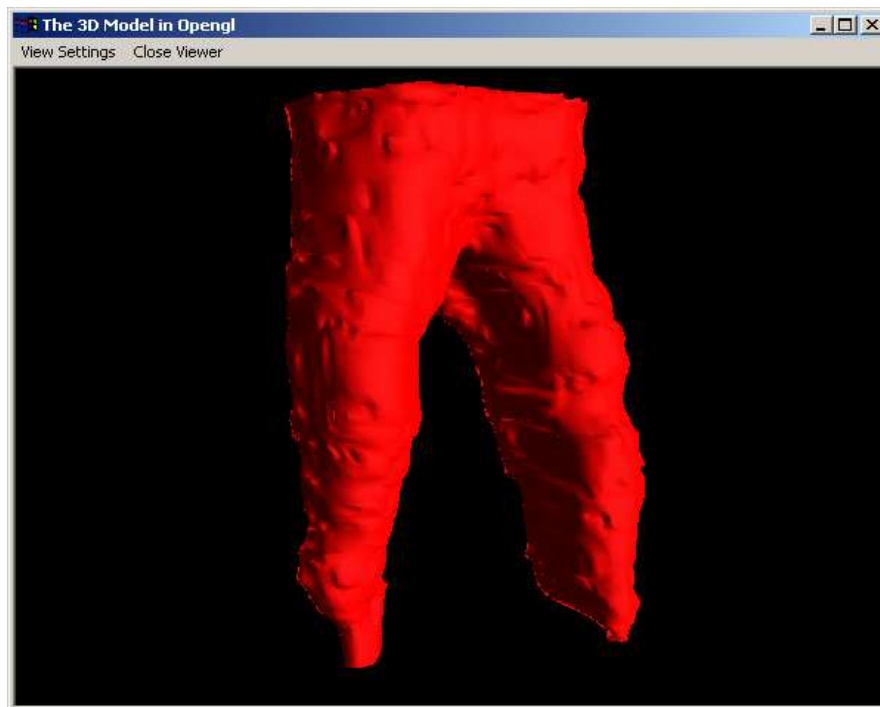


Figure 8: Displayed solid 3D surface model.

*Wireframe* command: It displays a 3D surface model as wireframe (Figure 9).

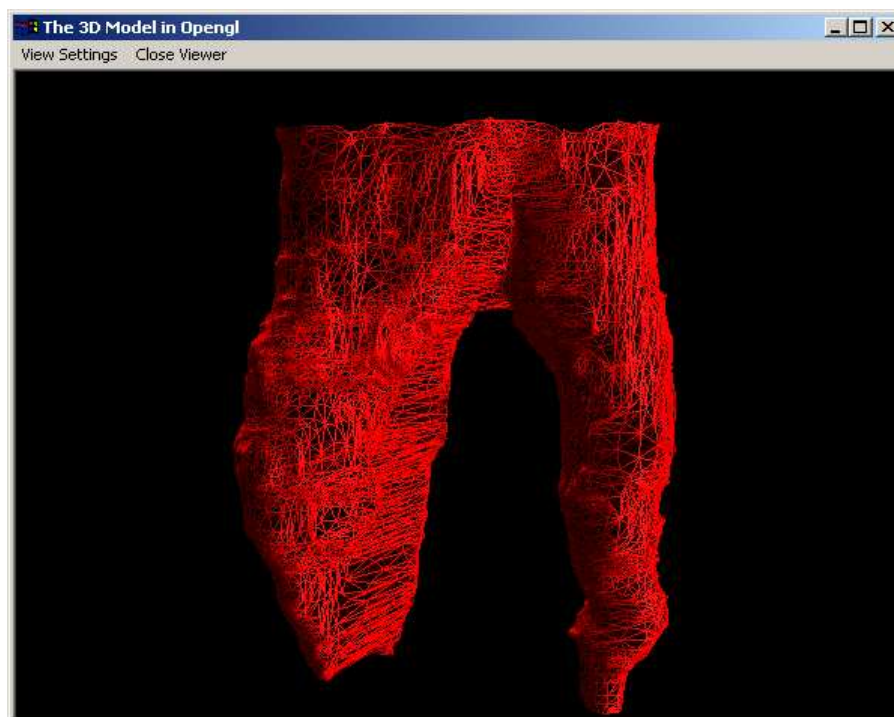


Figure 9: Wireframe display of a 3D surface model.

*Vertices* command: It displays only the vertices of a 3D model (Figure 10).

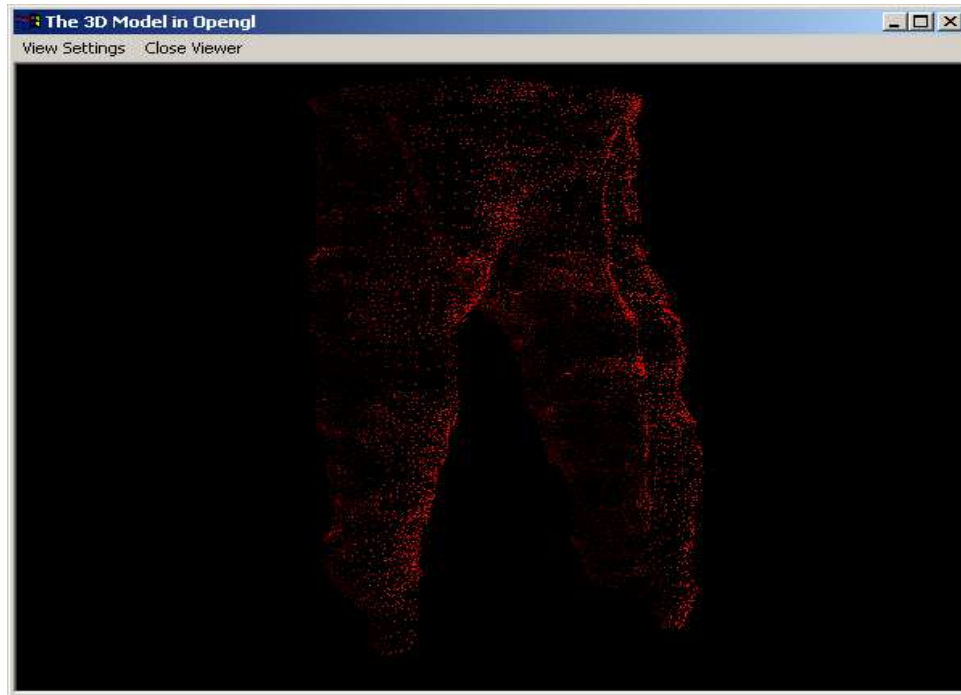


Figure 10: Vertex display of a 3D surface model.

*Close Viewer* menu:

*Close* command: It closes the OpenGL platform.

When pressing the *Show 3D Model* button, besides having the 3D model displayed, a short message '*Wait, the 3D Model is displayed*' is presented on the left side of the button, inside the small box, otherwise, a short message '*3D Model is not displayed*' is presented on the right side of the button.

*Save 3D Model* tab:

*Folder* text field:

The user must select the destination directory where the 3D model will be saved (Figure 11). The destination directory can be selected by the browse function.

The name of the file is provided in the *File Name* text field. In case of missing destination path or file name when the user has chosen to export the result in a file, an error message is displayed.

*Export Model* panel:

*Export model to wrl* file checkbox: If checked, the 3D model is exported to a VRML2 format file.

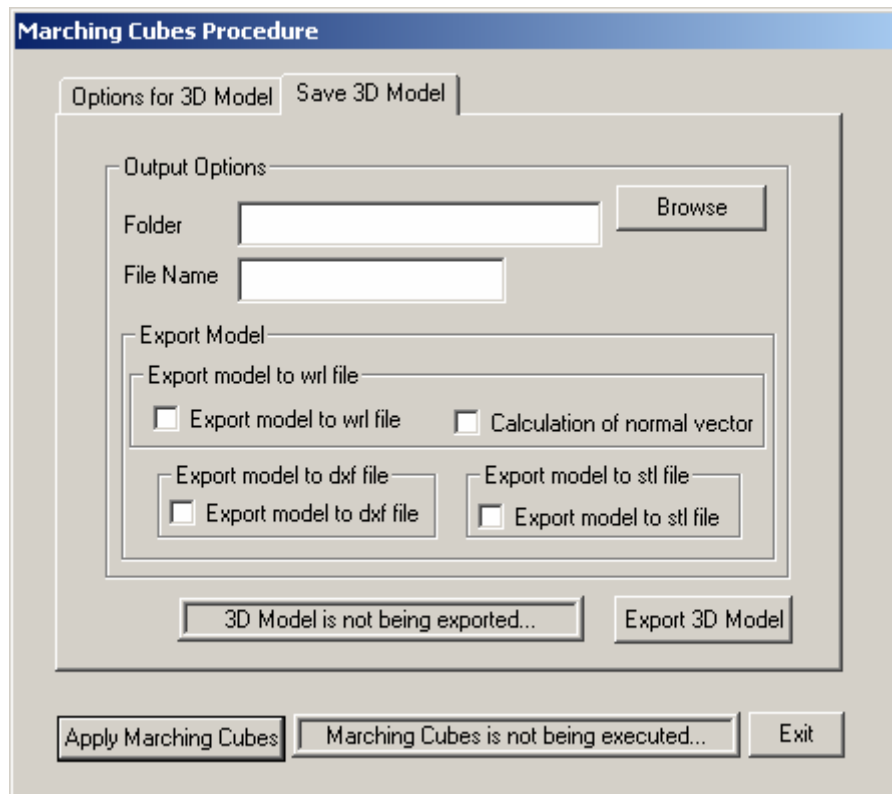


Figure 11: The *Save 3D Model* dialog box.

*Calculation of normal vector* checkbox: If checked, it supplies the exported file with the normal vectors that have already been calculated. Otherwise, the exported file does not carry normal vector information.

*Export model to dxf* file checkbox: If checked, the 3D model is exported to a AUTOCAD file format.

*Export model to stl* file checkbox: If checked, the 3D model is exported to a stereo lithography (STL) file format, that is used in 3D scanners as well as in 3D printers.

*Export 3D Model* button: When pressing the *Export 3D Model* button, besides having the 3D model being exported, the message *Wait, the 3D Model is being exported* is presented on the left side of the button, inside the small box, otherwise, the message *3D Model is not being exported* is presented on the right side of the button.

*Apply Marching Cubes* button: When pressing the *Apply Marching Cubes* button, besides having the Marching Cubes algorithm executed, the message *Wait, Marching Cubes is being executed* is presented on the right side of the button, inside the small

box, otherwise, the message *Marching Cubes is not being executed* is presented on the right side of the button.

*Exit* button: It is used to exit the Marching Cubes module.

### **3. Error messages**

*Can not allocate internal buffer*: can not allocate memory for marching cubes procedure.

*fopen* error: Can not open file .

### **4. References**

[1] N.Nikolaidis, I.Pitas '3D image processing algorithms', Wiley 2000.