3D Surface modeling module

This module performs the dynamic surface modeling of a 3D object by surface deformations. The deformations performed exploit modal analysis [1]. The input volume for this module should be a grayscale (thresholded) volume, like the one shown in Figure 1.

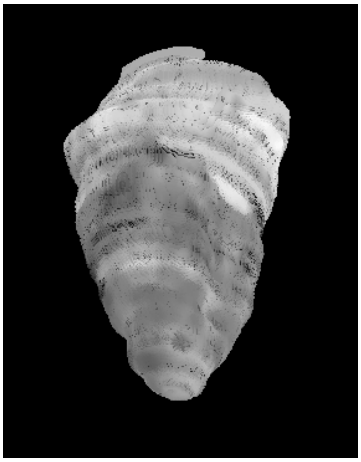

Figure 1: 3D object used for surface modeling.

1. Modal Analysis Method

This object surface modeling method is described in [1]. The 3D object is originally described by a 3D spherical surface containing N×M×L nodes. During deformation, this surface is fit to the 3D object surface. Once a volume containing a 3D object has been opened using *File>Open*, its surface modeling can be performed by selecting the option *Modules>Surface Deformation>Modal Analysis* from the main menu which brings up the Interactive Modal Analysis dialog box depicted in Figure 2.

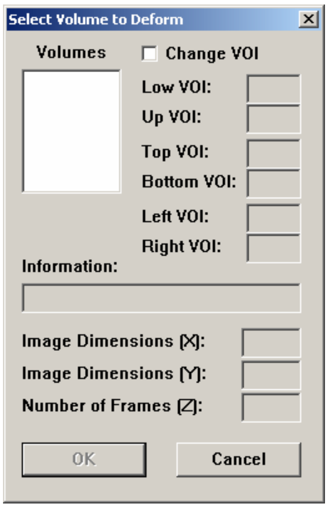

Figure 2: The Interactive Modal Analysis dialog box.

The dialog box is used to select the source volume buffer that contains the 3D object whose surface should be modeled. Afterwards, the *Model Properties* dialog box appears, which is used to provide the properties of the deformation model that is going to be used. The four parameters used in this dialog box are:

a) the characteristic value of the model, which characterizes how deformable the model will be. It should be greater than 0.
b) The percentage of the low-frequency eigenvalues used in the modal analysis algorithm.
c) The height and the width of the model (in number of nodes).

The dialog box can be seen in Figure 3.

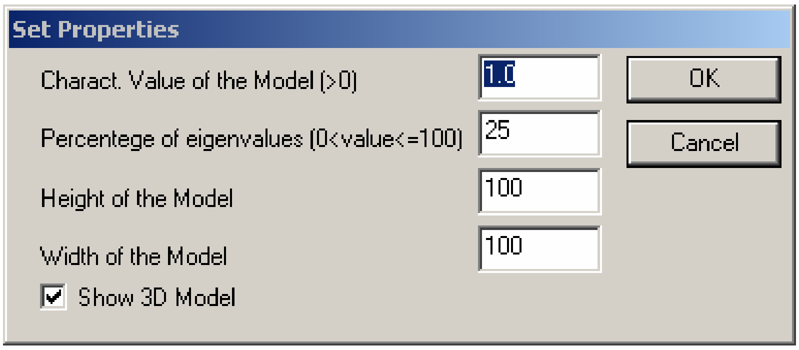

Figure 3: Model properties dialog box used by Modal Analysis.

Also in this dialog box there is the option *Show 3D Model*. If this option is checked, an OpenGL platform is opened, where the 3D surface model is displayed (see Figure6).

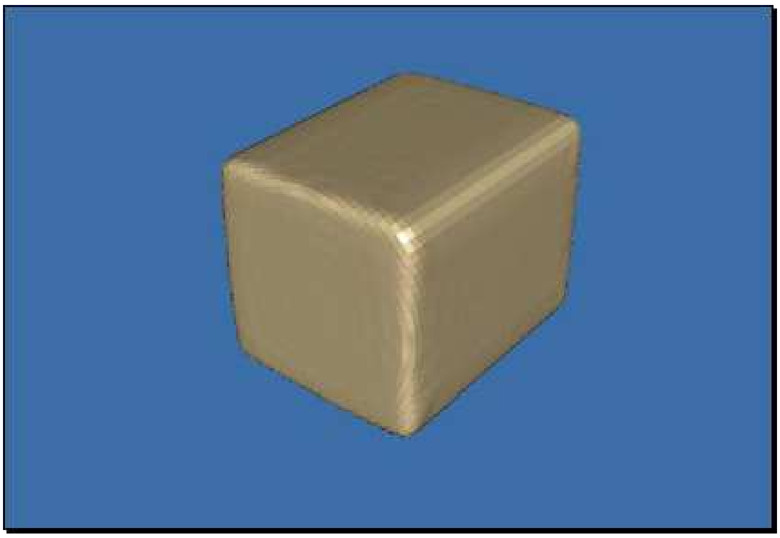

Figure 4: VRML Surface model of a cubic 3D object.

The derived surface of the volume is saved in a VRML file after prompting the user for the desired output file and path name, using a *Save Deformed Volume As…* dialog box. The obtained VRML output file of a volume containing a cube is shown in Figure 4.

The result of the surface modeling of the object shown in Figure 1 is illustrated in Figure 5.

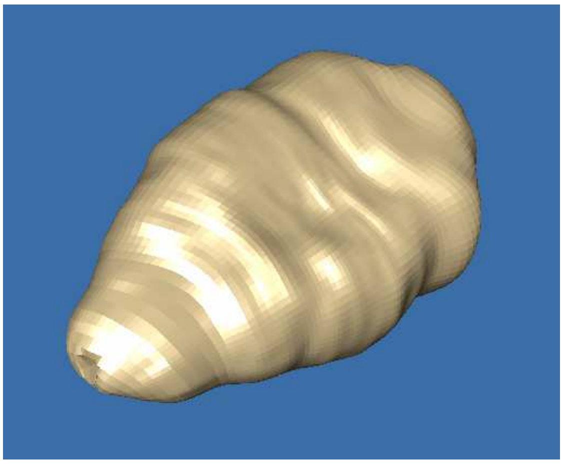

Figure 5: VRML Surface model of the object shown in Figure 1.

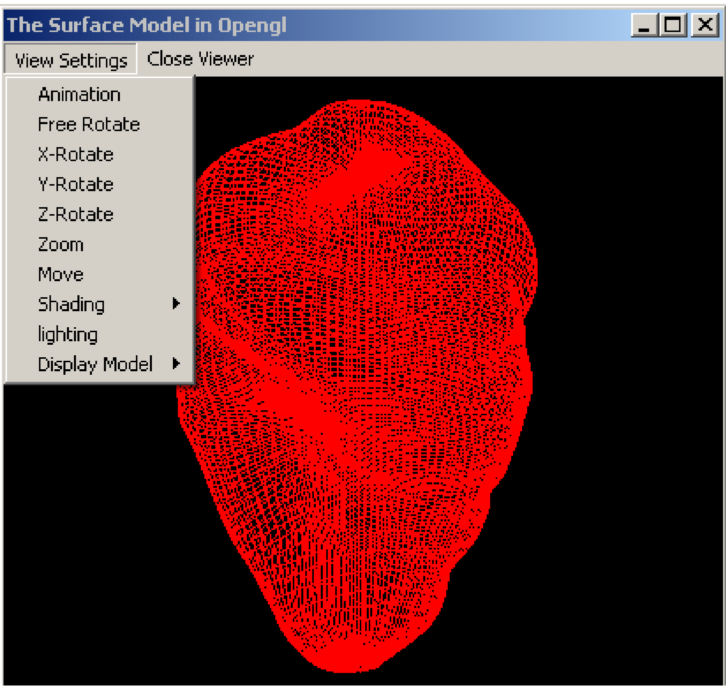

Figure 6: The Surface Model *in OpenGL* display window.

The *View settings* menu (Figure 6) contains useful commands for manipulating the 3D model. Each command of the menu is described in details below.

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

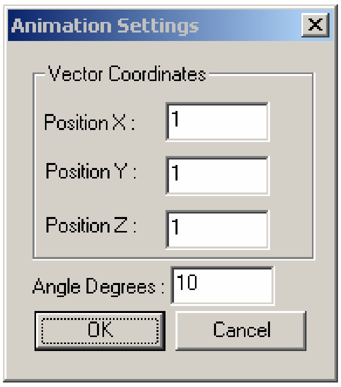

Figure 7: Animation Settings.

Its fields are:

Vector Coordinates panel:

Position X: It represents the X coordinate of the rotation axis.

Position Y: It represents the Y coordinate of the rotation axis.

Position Z: It represents the Z coordinate of the rotation axis.

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

Angle degrees: It represents the rotation angle in degrees. Its value must vary from 1 to 359 degrees. Otherwise, an error message is displayed.

Free Rotate command: It allows the user to rotate the 3D surface model freely 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 by moving the mouse to the upper side of the window and to zoom out by moving the mouse to the opposite side of the window.

Move command: It allows the user to move the model using the mouse.

Shading submenu:

Flat command: No smoothing of the surface model is applied.

Smooth tab: Smoothing of the surface model 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 a polygonal surface as a solid surface (Figure 8).

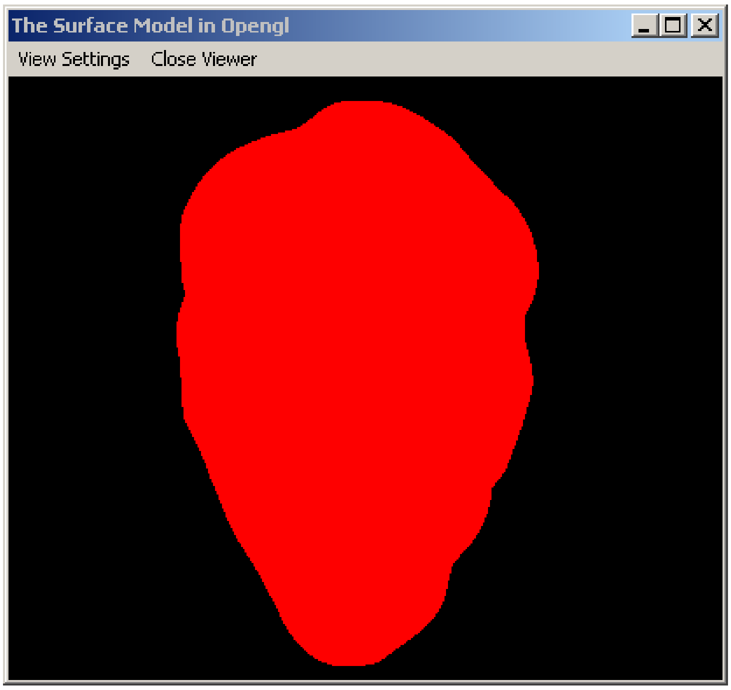

Figure 8: Displayed solid 3D surface model.

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

Close Viewer menu:

Close command: It closes the OpenGL platform.

2. Solve Equations method

This module performs dynamic surface modeling of a 3D object. The method used is described in [2]. The 3D object is originally described by a 3D spherical surface containing N×M×L nodes. During deformation, this surface is fit to the 3D object surface. The input volume for this module should be a grayscale (thresholded) volume.

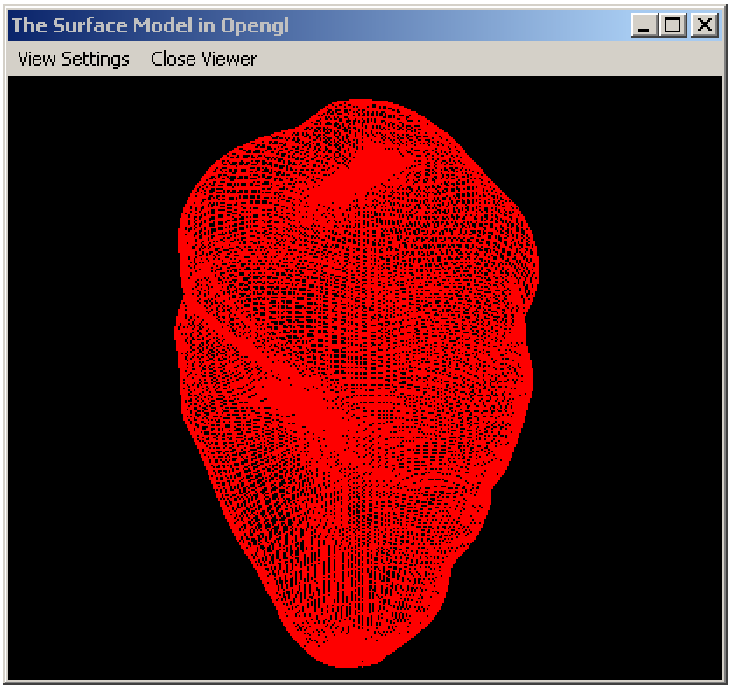

Figure 9: Wireframe display of a 3D surface model.

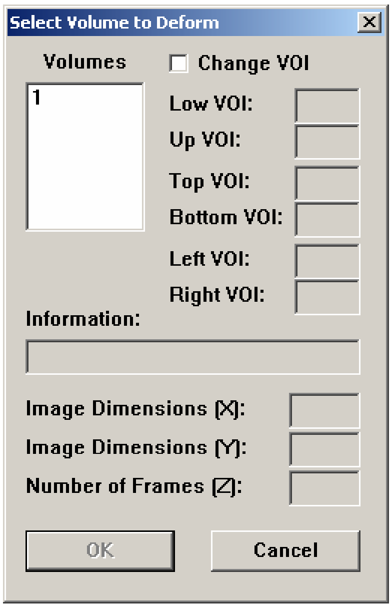

Figure 10: The Interactive Solve Equations dialog box.

Once a volume has been opened using *File>Open*, surface deformations can be performed by selecting the option *Modules>Surface Deformation>Solve Equations* which brings up the *Interactive Solve Equations* dialog box depicted in Figure 10.

The dialog box is used to select the source volume buffer containing the 3D object to be modeled. Afterwards, the Model Properties dialog box appears, which is used to provide the properties of the deformation model that is going to be used (the dialog box can be seen in Figure 11).

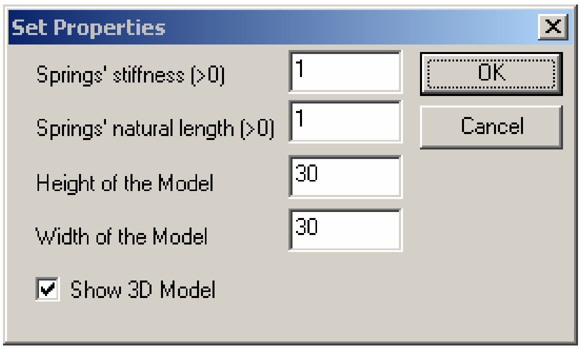

Figure 11: Model properties dialog box used by Modal Analysis.

The four parameters used in this dialog box are:

a) the *spring stiffness* (should be greater than zero).

b) The *natural length* of the springs used by the model (which must be positive).

c) The *height* and the *width* of the model (in number of nodes).

Also in this dialog box there is the option *Show 3D Model*. If this option is checked, an OpenGL platform is opened, where the 3D surface model is displayed (see Figure6).

The deformed surface of the volume is saved in a VRML file after prompting the user for the desired output file and path name using a *Save Deformed Volume As...* dialog box. The VRML output file of the 3D object of Figure 1 is shown in Figure 12.

The VRML output files can be viewed by using a VRML player.

Figure 12: VRML surface model of the object shown in Figure 1.

3. References

[1] S. Krinidis, I. Pitas. ‘Fast Free Vibration Modal Analysis of 2D Physics-Based Deformable Objects’. IEEE Transactions on Image Processing, to be published on March 2005.

[2] K. J. Bathe. ‘Finite Element Procedure’. Prentice Hall, Englewood Cliffs, New Jersey, 1996.