Tutorial

http://liris.cnrs.fr/gilles.gesquiere/wiki/doku.php?id=endex

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1. Endocast segmentation from a 3D mesh

1.1 Data

Download the 3D model of the skull and mandible of the type specimen of *Pan paniscus* in STL format (RG9338-skull.stl) which is freely available at: http://www.metafro.be/primates/downloads

More information is given in (Balzeau et al. 2009).

1.2 Extra software

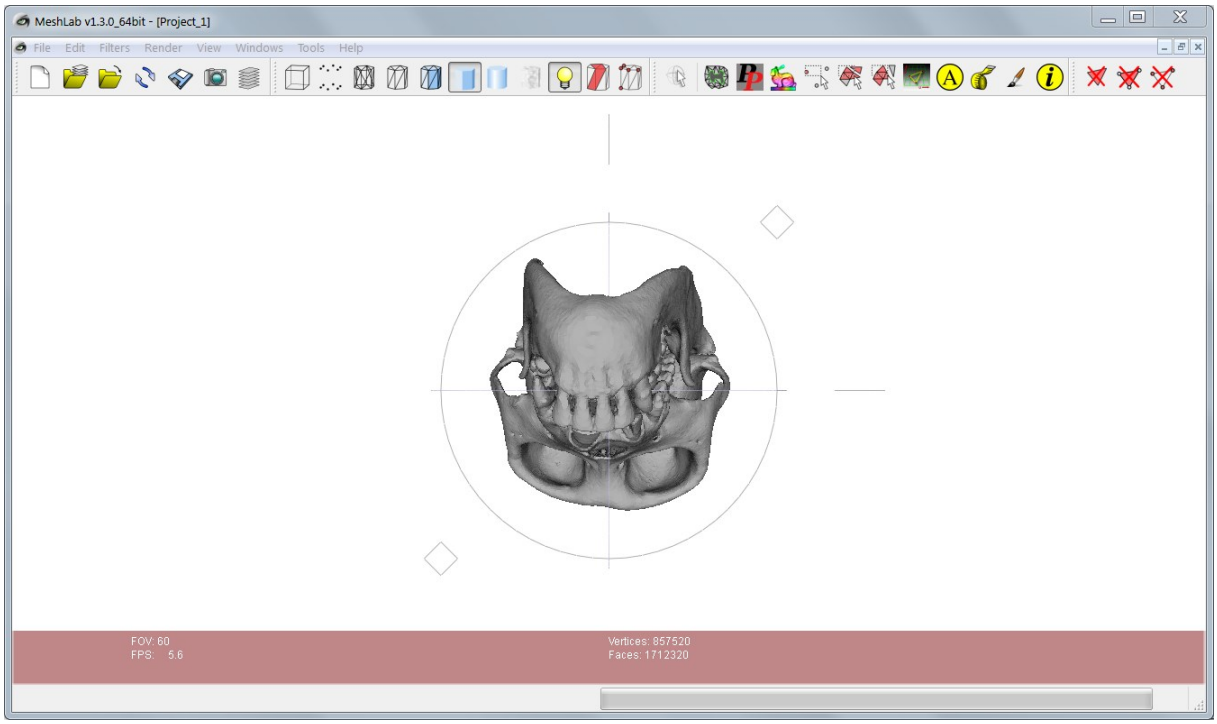
- For format conversion, preprocessing (see section 1.3) and visualization, you can use the *MeshLab* software which is freely available at: http://meshlab.sourceforge.net/
- For visualization, in particular with transparency functions, you can use the *Paraview* software which is freely available at: http://www.paraview.org/

1.3 Preprocessing

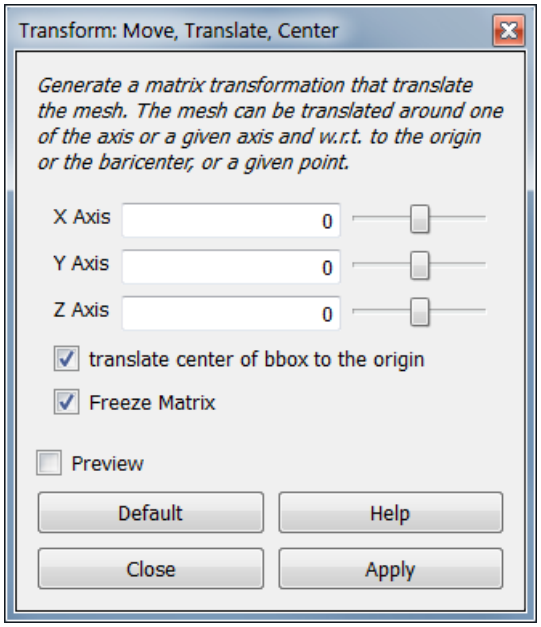
The preprocessing step consists in:

- Centering the 3D mesh (i.e. the center of the 3D mesh is set at the location (0,0,0)) in order to make the initial positioning of the deformable sphere easier;
- Converting the 3D mesh in a format which is readable by *Endex*.

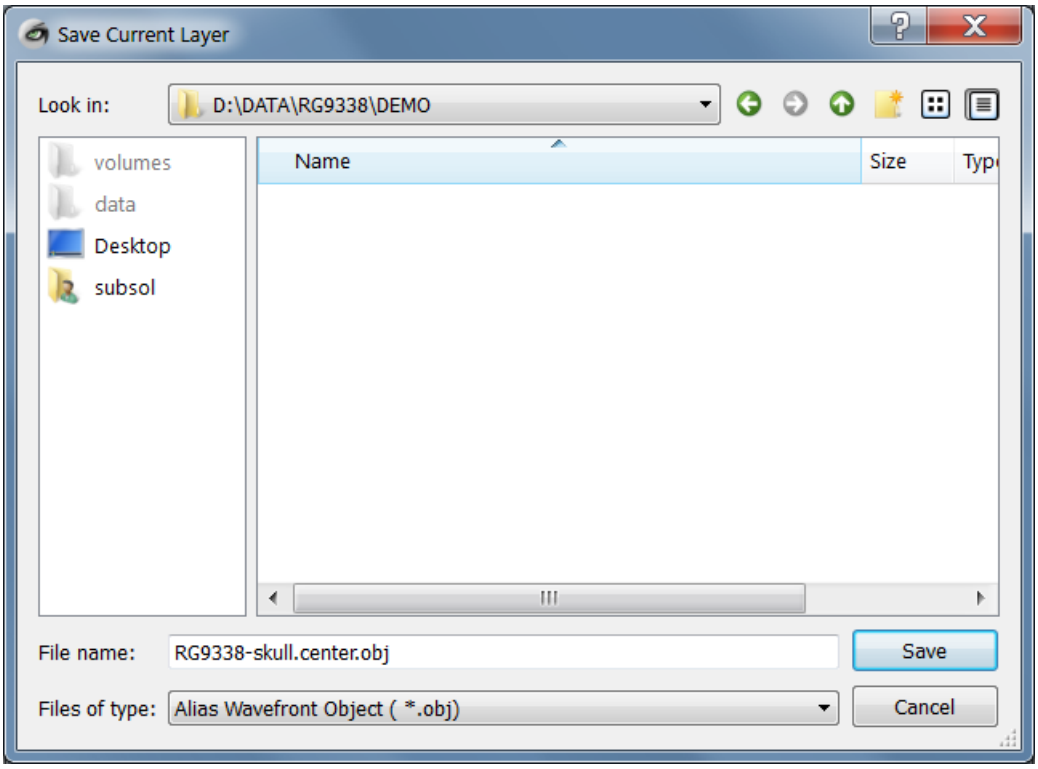
➢ Run *MeshLab*
➢ File/Import Mesh <RG9338-skull.stl>



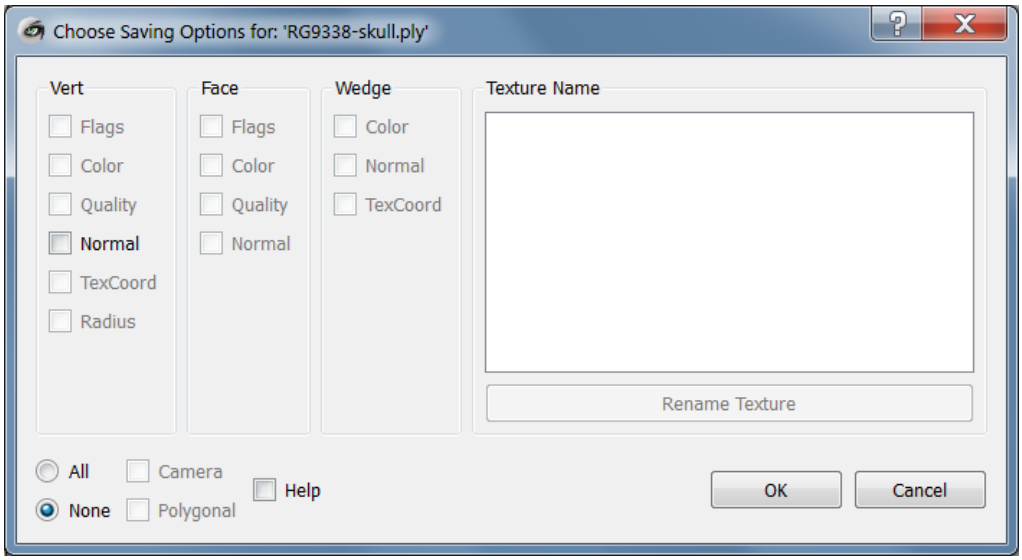
- Filters/Normal, Curvatures and Orientation/Transform: Move, Translate, Center
- Tick “translate center of bbox to the origin”
- Tick “Freeze Matrix”



- Click on “Apply” and the mesh disappears from the screen as it is translated outside the field of view.
- File/Export Mesh As… (e.g. RG9338-skull.center.obj)
- Select the “obj” format

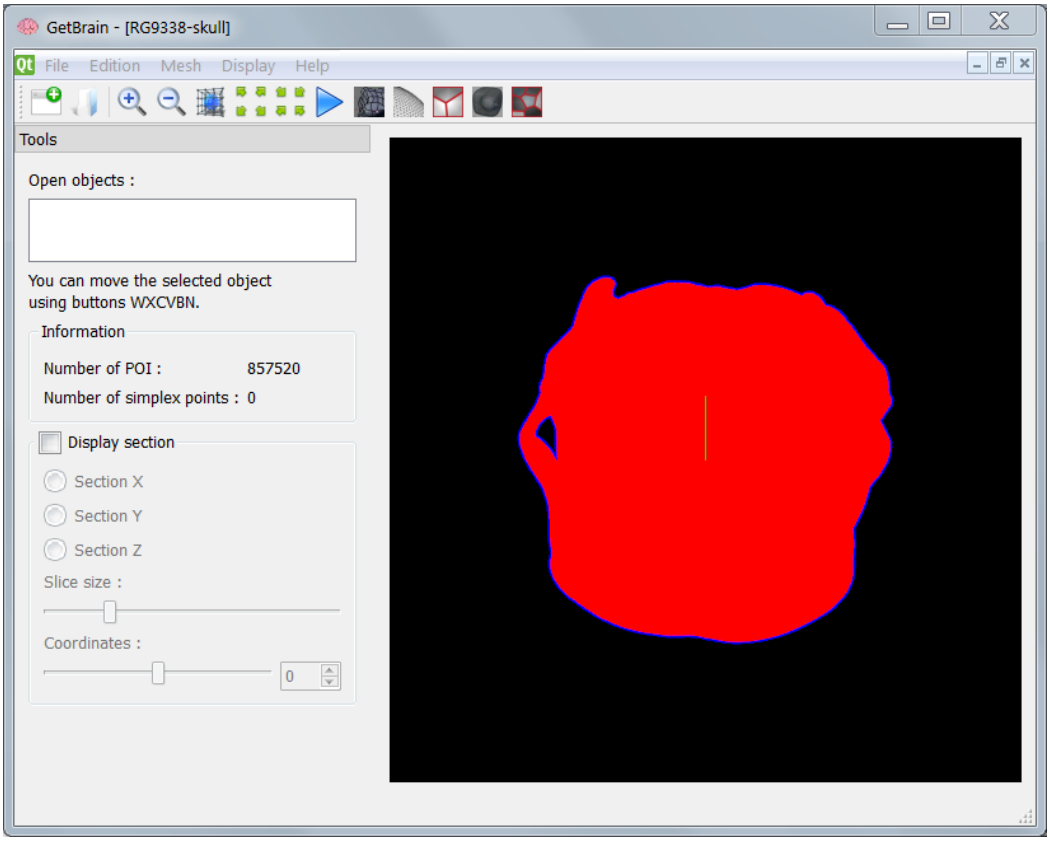


- Tick “None”



1.4 Running the endocast segmentation software

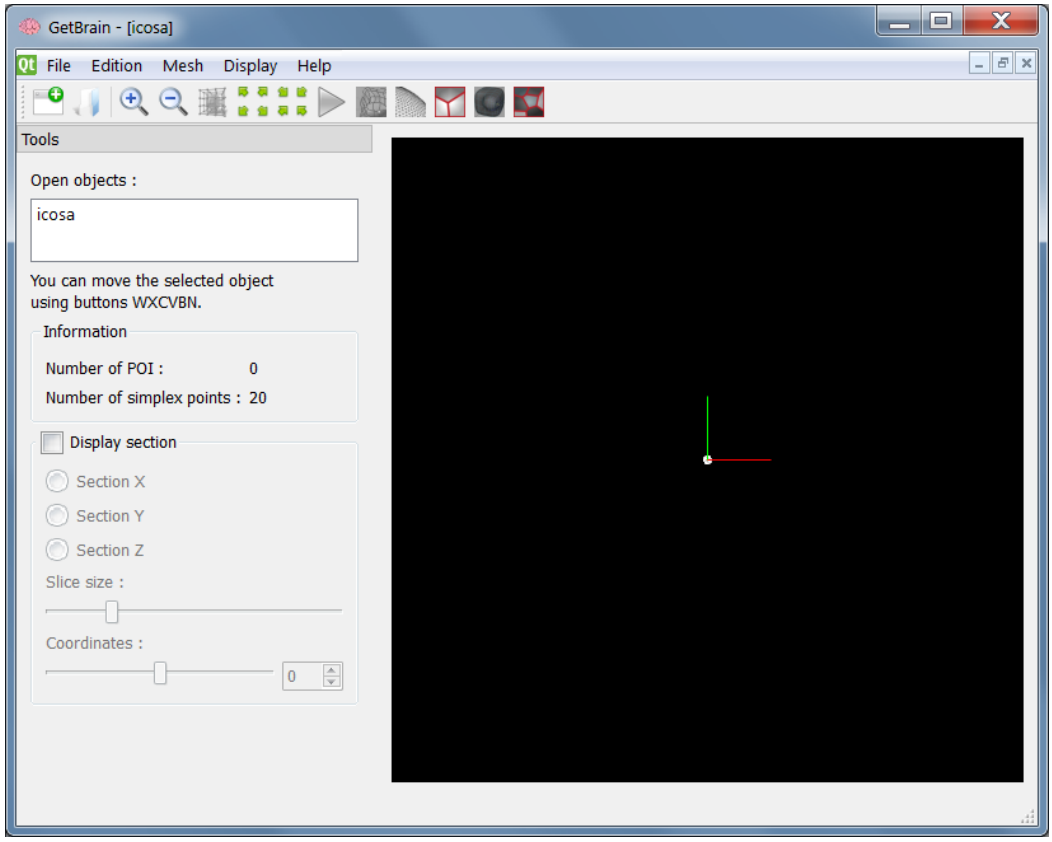
- Run *Endex*
- File/Open <RG9338-skull.center.obj >
- Mesh/Conversion/Create a point cloud



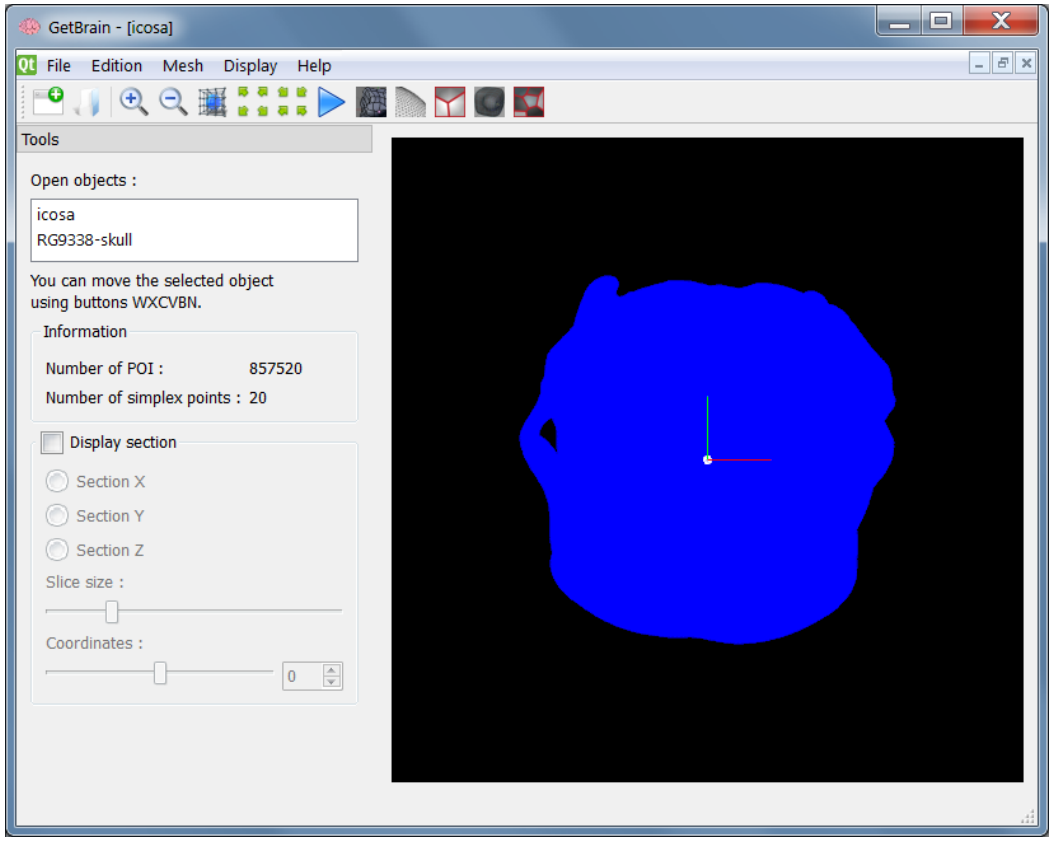
- File/Export the point cloud (e.g. RG9338-skull.center.pts)
- Quit

This step is essential to convert the 3D mesh from its initial OBJ format into the required PTS format.

- Run *Endex*
- File/Open <icosa.smm>
  You can see in white the deformable sphere which is located at the coordinates (0,0,0).

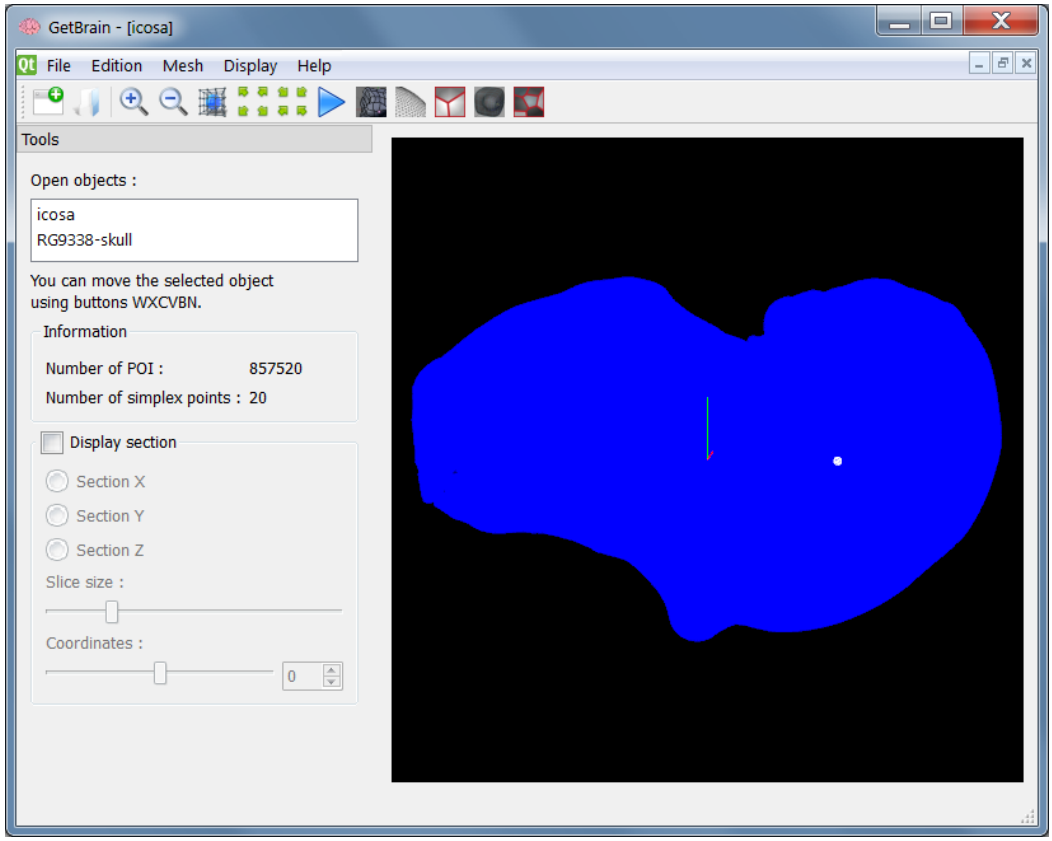


- File/Import/New Point Cloud <RG9338-skull.center.pts> (warning: it may take 30 seconds)
  You can see now the points of the 3D mesh in blue.

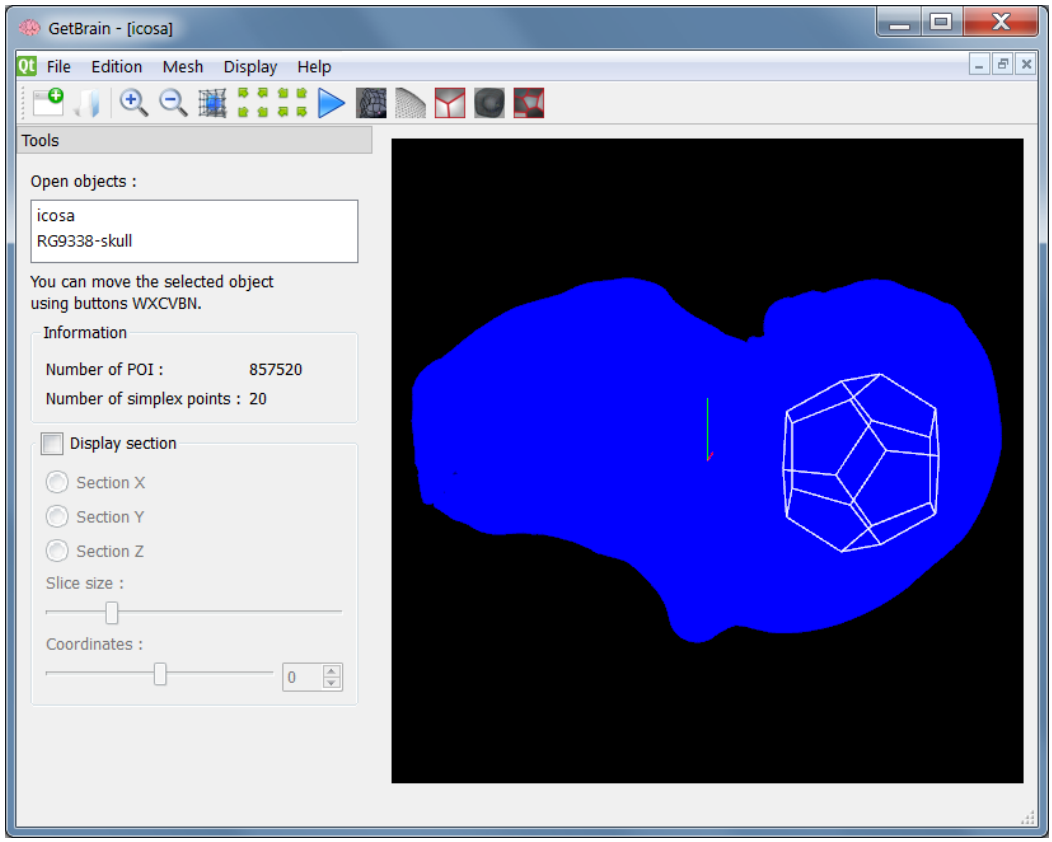


By dragging (clicking on the left button + moving) the mouse, you can rotate the camera (i.e. the field of view) around the origin. By clicking on  you can zoom and unzoom.

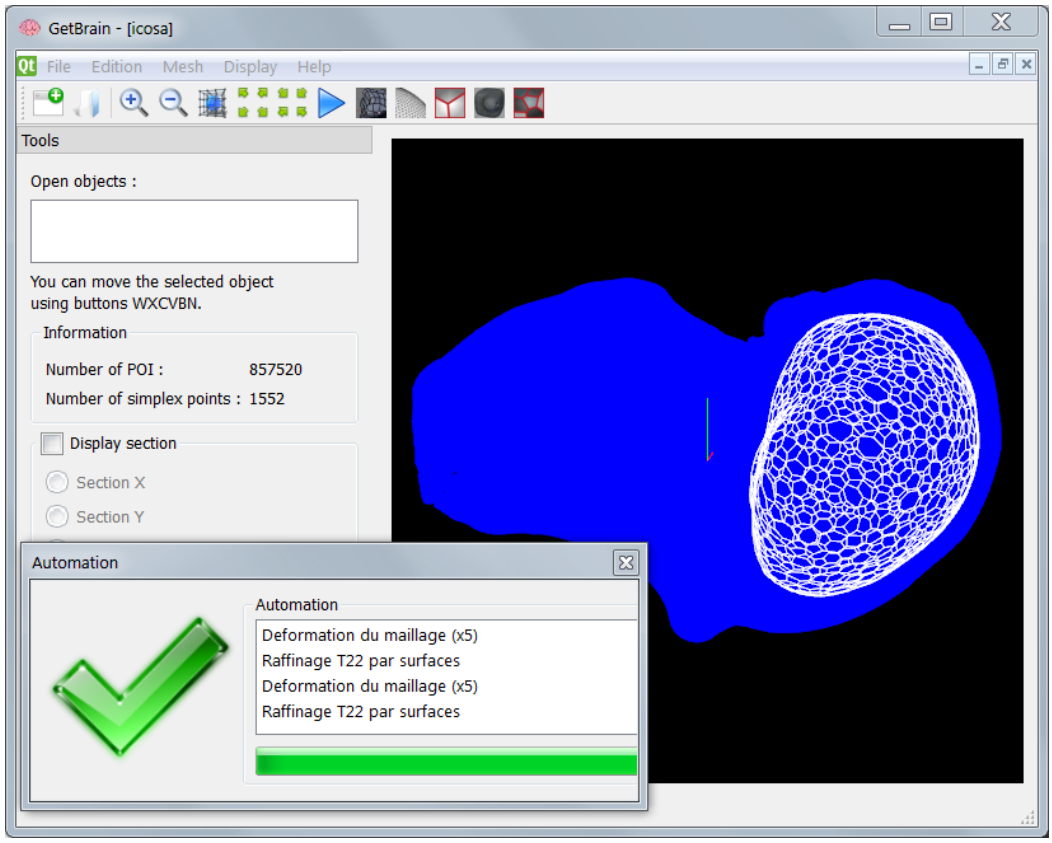
- Use the keys W/X C/B B/N to move the sphere in order to position it in the middle of the endocranial cavity. In this example, you have to push several times the key 'B'. You can move the camera to assess if the sphere is correctly positioned.



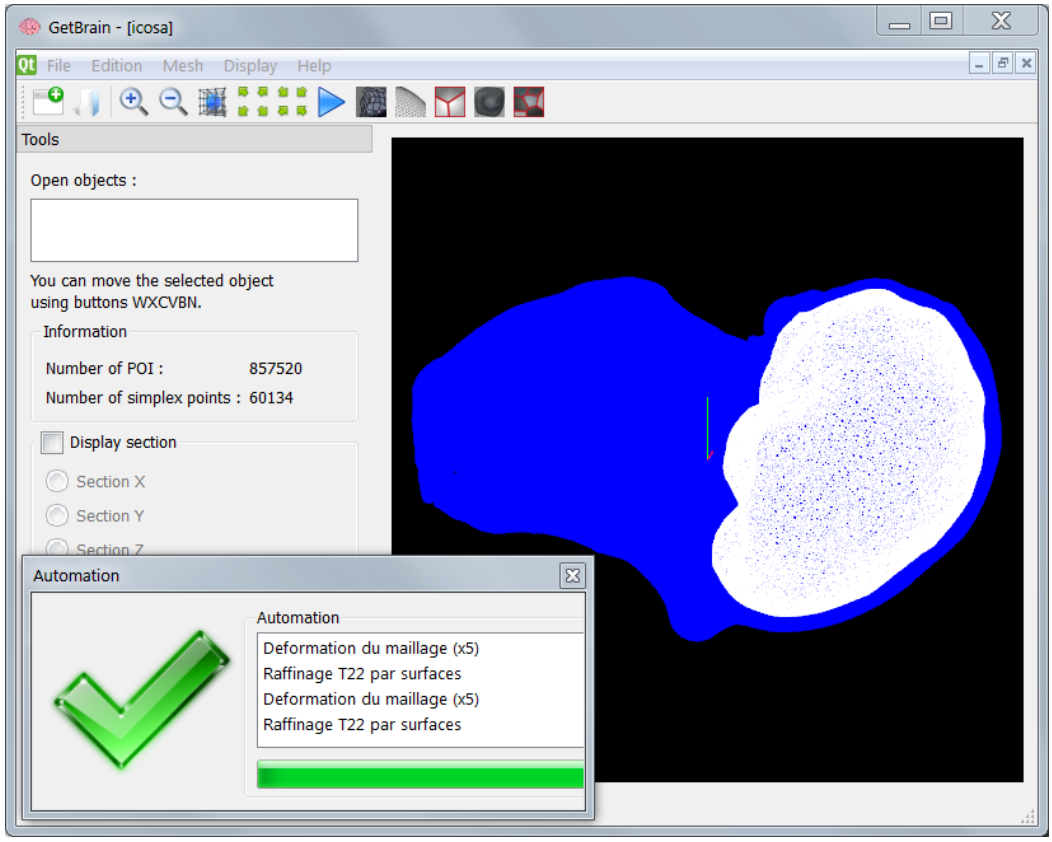
- To finish the initialization, click on  to enlarge (resp. reduce) the sphere diameter in order that it is around half of the endocranial cavity one.



- Start the automatic deformation process by clicking on  . You can see the evolution of the deformation (it may take around 30 seconds).



- Click on "Close"
- Stat another automatic deformation process by clicking on  . It will take more time as there is much more points on the sphere (around 1 to 3 min).

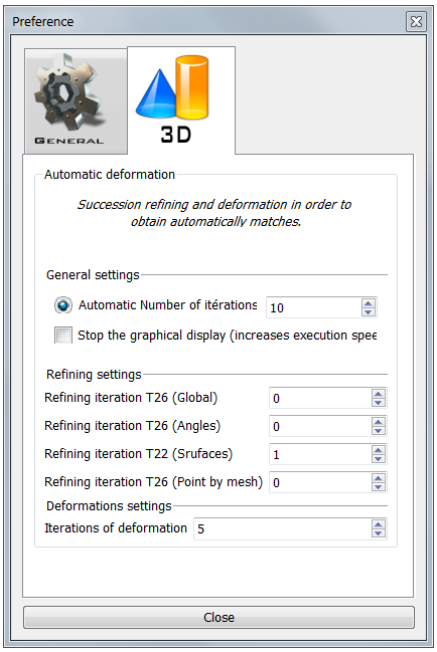


- Click on "Close"
- File/Export the mesh (e.g. RG9338.endocast.obj)
- Choose the .obj format (warning: saving the file can take up to 5 min).

Of course, you can launch supplementary automatic deformation steps. But be careful, they will take more and more time. In general 3 steps give accurate results.
In our example, with 2 steps, we get a 3D mesh of 90,203 vertices and 180,402 faces.

You can also click on  to continue the deformation without refining the deformable. This could be useful if you want to retrieve details of a surface without adding any vertex. When you cannot distinguish any deformation of the white surface, you have just to click again to stop the process.

In Edition/Preferences, you will find all the parameters of the deformation process:



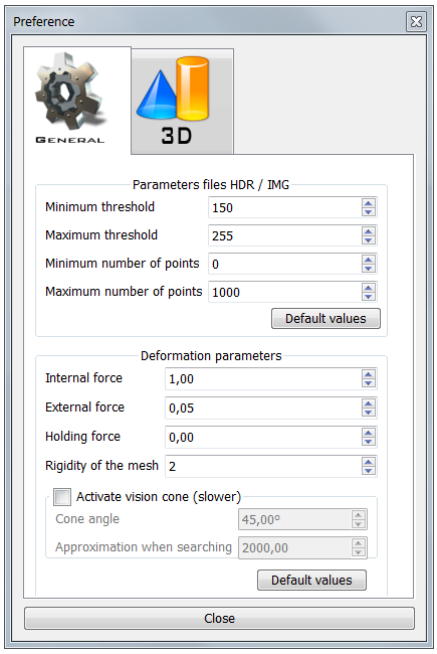
When you click on  , you run <automatic number of iterations> iterations sequentially composed of:

- 4 different types of refining processes (called T26 global, T26 angle, T22 surface and T26 point by mesh) which add new points to the deformable mesh in order to improve the geometric accuracy;
- A number of deformations.

In this example, there will be 10 steps composed of (1 refining iteration 22 + 5 deformations).

If you want to be more precise, you can increase <Iterations of deformation>.

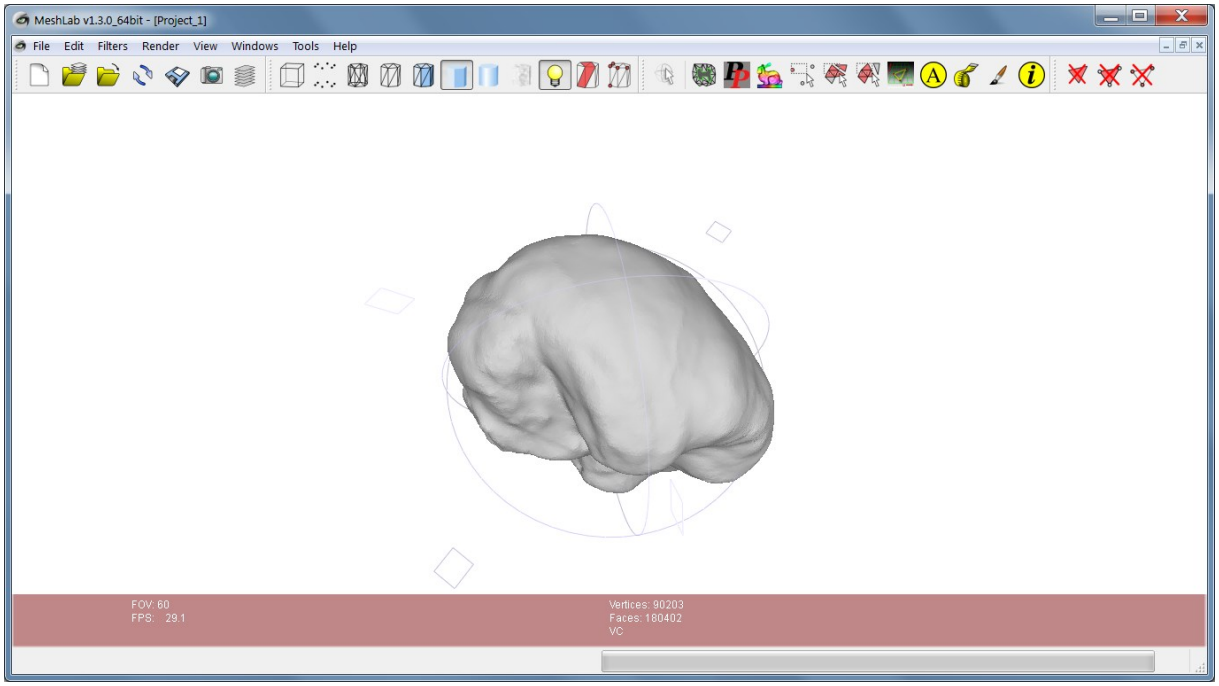
Be careful if you increase <Automatic Number of iterations> or <refining iterations>. The number of points in the deformable mesh can grow quite fast and the deformation may become very slow.



These parameters are very technical to tune.
More explanations will be given in future version of this document.

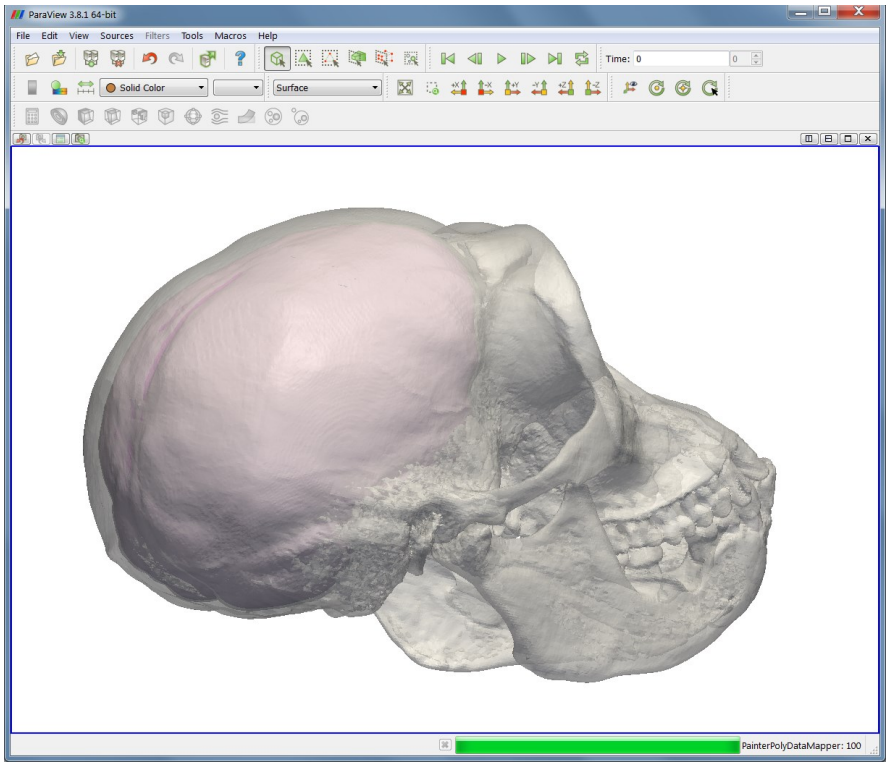
1.5 Visualizing the results

- Run *MeshLab*
- File/Import Mesh <RG9338.endocast.obj>

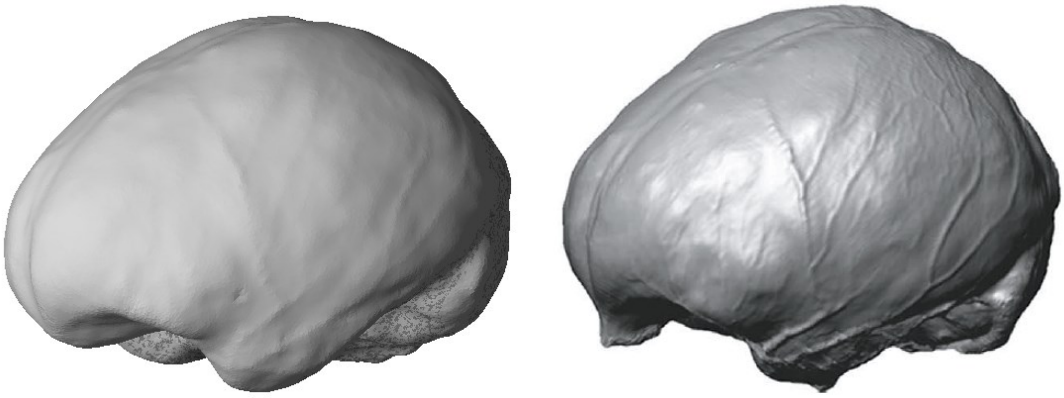


- Run *Paraview*
- File/Open < RG9338.endocast.obj>
- File/Open <RG9338-skull.center.obj>

By clicking the corresponding name in the “Pipeline Browser” windows, you can select the Display features in the “Object Inspector” window. By tuning the opacity of the skull to 0.5, you see the endocast by transparency.



You may compare the result with the endocast presented in Figure 1.d of (Balzeau and Gilissen, 2010).



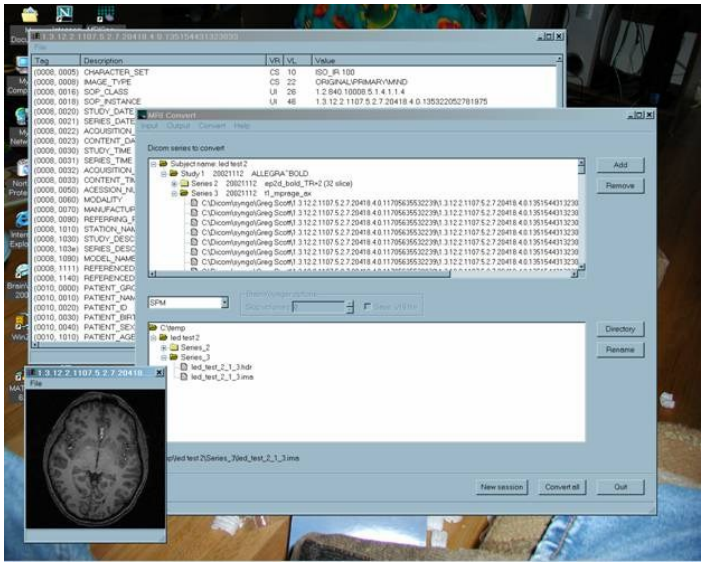
Endocast segmented by *Endex* / Endocast presented in (Balzeau and Gilissen, 2010) (Figure 1.d)

2. Endocast segmentation from a 3D image

In fact, with Endex, you can read directly a 3D image in the Analyze format, threshold it and get directly a point cloud in PTS format. You can then follow the procedure from the top of page 4.

2.1 Converting a 3D image in DICOM format into Analyze format

You may use the *MRIConvert* software which is freely available at http://lcni.uoregon.edu/~jolinda/MRIConvert/ and runs on Windows and Linux. This software is regularly updated.

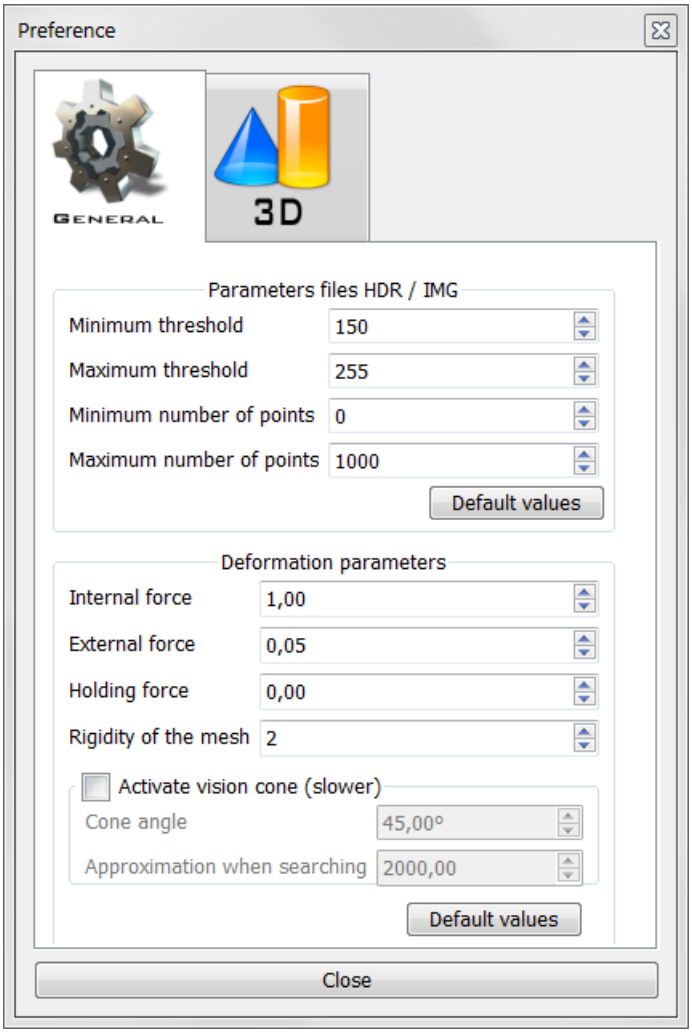


1. Define the folder where is the DICOM series by *Input/Add Folder*
2. All the files of the folder will be analysed. Validate by *Okay*.
3. Select *Analyse 7.5* in the format window in the middle.
4. Select the folder to output the result file by *Directory.*
5. Click on *Convert all*

Another possibility is to use the *Fiji* software which is freely available at http://fiji.sc/Fiji and runs on Windows, MacOS and Linux.

2.2 Getting a point cloud with Endex

- Run *Endex*
- Edition/Preferences/General



- You can set a minimum and maximum threshold as a maximum number of points.
- File/Open <file.hdr>
- The point cloud appears on the screen. Follow now the procedure from page 4.

3. Bibliography

(Balzeau and Gilissen, 2010) Balzeau, Antoine, Emmanuel Gilissen, Wim Wendelen, and Walter Coudyzer. 2009. “Internal cranial anatomy of the type specimen of Pan paniscus and available data for study.” *Journal of Human Evolution* 56 (2) (February): 205-208. doi:16/j.jhevol.2008.07.013.

(Prima et al., 2011) S. Prima, R. Holloway, G. Subsol, G. Gesquière, T. Schoenemann, B. Combès, J. Monge, J. Braga. “New 3D automatic methods for the analysis of the endocranial shape and its relationship with ectocranial structures: assessment and preliminary experiments”. 80th Annual Meeting of the American Association of Physical Anthropologists, Minneapolis (U.S.A.), April 2011. Abstract published in American Journal of Physical Anthropology, p. 243-244, Vol. 144 Issue S52, 2011.

(Subsol et al., 2010) G. Subsol, G. Gesquière, J. Braga, F. Thackeray. “3D automatic methods to segment virtual endocasts: state of the art and future directions”. 79th Annual Meeting of the American Association of Physical Anthropologists, Albuquerque (U.S.A.), April 2010. Abstract published in American Journal of Physical Anthropology, p. 226-227, Vol. 141 Issue S50, 2010.