MorphoDig

Tutorial 06: tagging objects containing unconnected regions

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Contents

Tutorial 06 includes:

- One .ntw (MorphoDig project) file

- One .vtk surface file representing a cranium of *Mus musculus*

- One .pos (position) file

- One .tgp (tag map) file

- One .ori (orientation helper labels) file

- The present .pdf document

6.1 "Unconnected regions"

By "objects containing unconnected regions", this tutorial refers to surface files containing sub-regions separated in space.

6.2   About the specimen

The surface file enclosed in this tutorial represent three-dimensional reconstruction of the cranium of the fetus of a house mouse (*Mus musculus*) from the collections of the ENS-Lyon. The 3D data were obtained by computerized microtomography at the MRI µ CT platform housed at the ISEM. Before using this tutorial, please download and read MorphoDig User Guide. The specimen (E17) was published in Hautier et al. [2014].

6.3   A brief overview of enclosed files

Download and unzip the files associated to this tutorial. Open MorphoDig.

6.3.1   Mouse fetus cranium surface and position files

You may open the enclosed .vtk surface file (File -> Surface -> Open Surface, then select "Mouse_cranium.vtk", or drag and drop this file in the 3D main window). When opened this way, the corresponding opened surface object is drawn grey, which indicates that this surface is selected. You may interact with selected objects in different ways (see MorphoDig user guide for further explanations).

By default (🎥), the camera rotates around the center of mass of all opened objects. This behavior is useful when the center of mass of an object (or of several ones) is far from the origin of the coordinate system. But by pressing the camera button (🎥 -> 🎥), the camera will revolve around the center of the coordinate system (x=0, y=0, z=0). The display grid is drawn using different colors depending on the camera rotation center (see Fig. 6.1 p.4).

As a general rule, when opening a new object, it is strongly advised to change its position in order that it matches the 6 predefined camera positions :

🧑 view object from right side

🧑 view object from left side

💀 view object from front side (default camera position)

🧑 view object from back side

🧑 view object from above

🧑 view object from below

In "object interaction mode(⤯)", selected objects can be translated and rotated using the mouse left and middle buttons (in landmark 🖱 and camera 🖱 selection modes, you also need to maintain "CTRL" button pressed while dragging the left mouse button to achieve rotation and translation of selected objects). Alternatively, you may also use the "yellow sliders" located
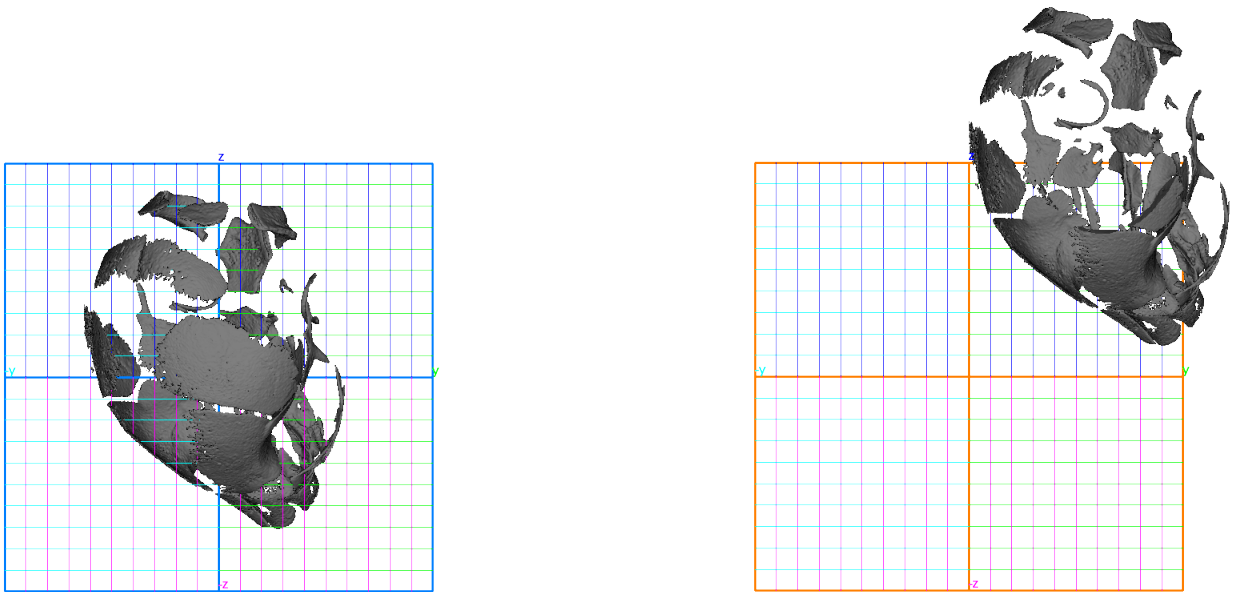
Figure 6.1: Grid display color. Left: when the camera revolves around the center of mass of all opened objects, the grid has a blue outline. Right: when the camera revolves around the origin of the coordinate system (x=0, y=0, z=0), the grid outline is displayed in orange.
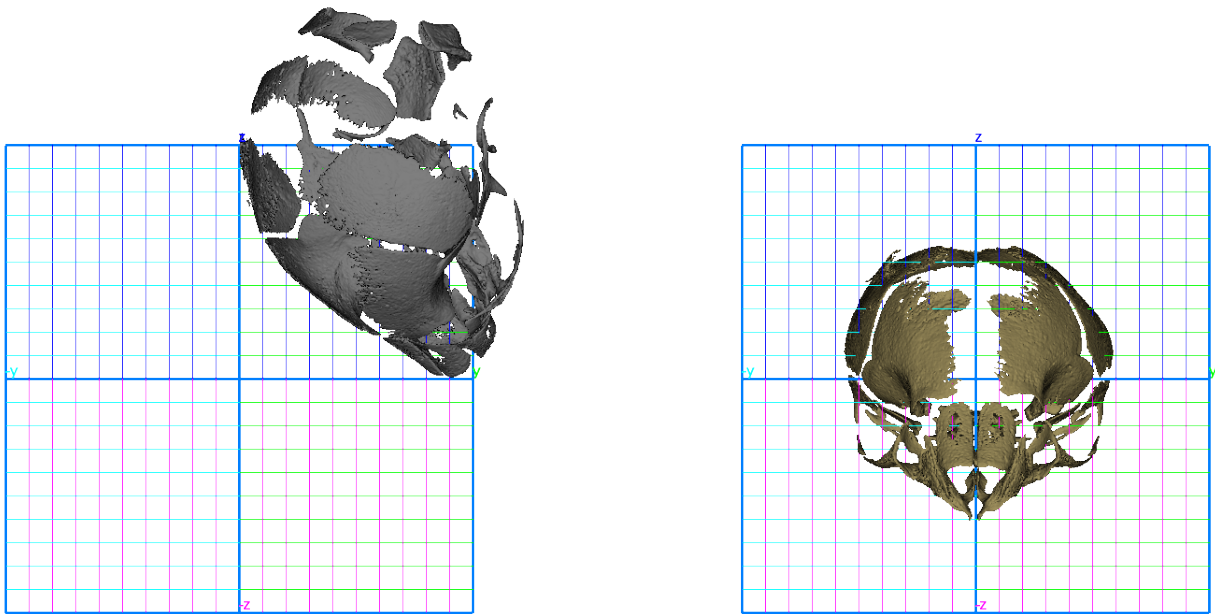
Figure 6.2: Surface orientation and .POS files. Left: the mouse cranium positioned in 3D space in the same orientation as it was CT-Scanned. Right: the same cranium in "biologically-relevant" orientation.

on the right side of the 3D main window to accomplish rotation and translation of selected objects. Rotation is achieved around the global center of mass of all currently selected objects.

The present tutorial contains a .pos (position) file, which you may open in order to place correctly the house mouse cranium (File -> Position-> Open Position for selected surfaces, then choose "Mouse_cranium.pos", see Fig. 6.2 p.5). All opened surfaces can be unselected by pressing "CTRL +D", or selected by pressing "CTRL +A". All selected objects can be deleted by pressing "Del".

6.3.2   Mouse cranium project file

The present tutorial contains a project .ntw file, which may be useful to directly open the mouse cranium in a convenient position, to make it transparent. First, delete all currently opened objects (press "CTRL+A", then press "Del"). Then open the enclosed .ntw file (File->Open Project, then select "Mouse_cranium.ntw"). Once loaded, the mouse cranium surface file object is opened, is given the position enclosed in the "Mouse_cranium.pos" file, a color and a transparency. Note that the newly opened surface is unselected.
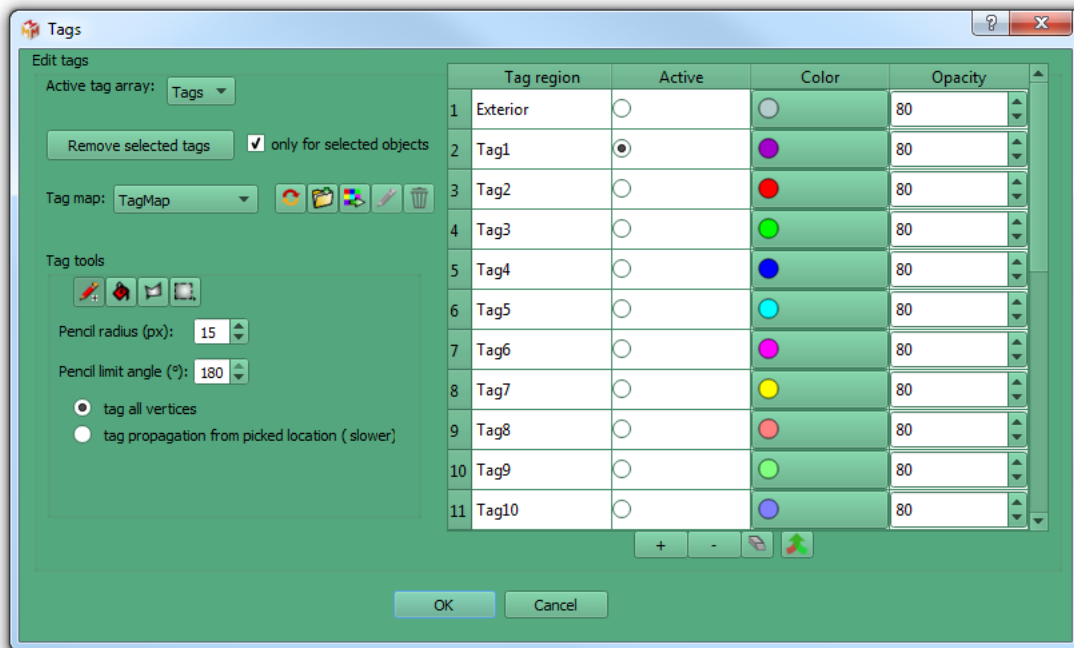
Figure 6.3: Tags window.

6.3.3   Mouse tag map file

All vertices of different biological structures can be given a specific integer values (0, 1, 2, 3 ...), in order to identify them. Such integer arrays are referred to as "tag arrays". A given unselected surface can be colored using the currently active tag array (identified by its "name"), if that surface contains a tag array of that name. To do so, the array display mode button must be pressed (), and a **tag** array must be selected as the currently active array (ex:). The way tag arrays are translated into colors can be set up using tag maps, also referred to as "Lookup tables" (LUT) or color transfer functions. Such a LUT is enclosed within the tag map file ("Mouse_fetus.tgp"). Open this file ("File->Tag maps->Import tag map", or drag and drop this file directly in the 3D main window). Then open the tags window ("File->Tags->Open Tags window", or click on "". The Tag window should open (see Fig. 6.3 p.6), and should contain the tag names and associated colors defined in "Mouse_fetus.tgp". See MorphoDig user guide for further explanation regarding the Tags window.

6.3.4   Mouse cranium .ori file

The present tutorial contains a .ori file, which contains orientation labels for the coordinate system orientation helper. You can load this file the enclosed .ori file ("File->Orientation helper labels -> Open Orientation labels", then select "Mouse_fetus.ori"). Once loaded, the system coordinate orientation helper will show the following labels :

+z axis : dorsal

-z axis : ventral

+y axis : left

-y axis : right

+x axis : proximal

-x axis : distal

You may set your own orientation axis labels with the "Edit orientation labels" window (Edit-> Edit orientation labels)

6.4   Tagging unconnected surface regions with MorphoDig

Contrary to "scalar arrays", tags are usually drawn manually with "painting tools".
For convenience purposes, as selected surfaces are drawn "grey" in MorphoDig, unselected surfaces objects can be tagged (tagging uniform "grey" objects without visual feedback would be uneasy). Tagging is the only way to modify an unselected surface in MorphoDig.

6.4.1   Create a new empty tag array

First, select the cranium *Mus musculus* and click on "Tags->Create new empty tag array for each selected surface". Here, you may choose a name different from "Tags", as this array already exists. This option will create a new "empty" tag array. "Empty", in this context, means that all vertices are assigned to the "Exterior" tag (tag=0).
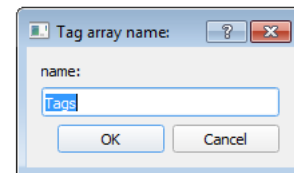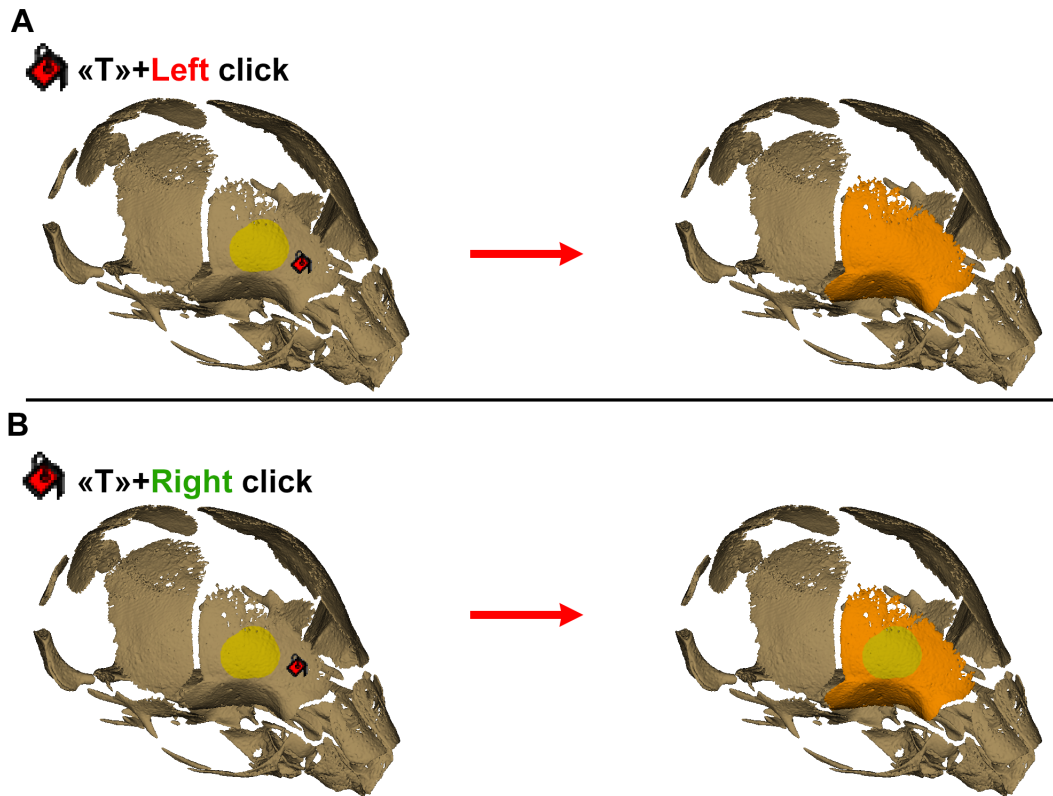
Figure 6.5: Creating a new tag array

   Select the newly created tag array as the currently active array, and unselect the surface representing the inner ear of *Mus musculus*

6.4.2   Open the Tags window

Click on "File->Tags->Open Tags window", or click on "". The Tag window should open (see Fig. 6.3 p.6). In this tutorial, you will use the paint bucket tag tool ("").

Figure 6.4: Tags tutorial. **A:** The paint bucket tag tool was used (T + left click pressed = color override). Note that a part of the frontal bone that was tagged in yellow (left) is now tagged in orange (right). **B:** The paint bucket tag tool was used (T + right click pressed = **No override**). Note that all vertices that were tagged in yellow (=a part of the frontal bone) remain tagged the same way when "color override" option is deactivated.

6.4.3   Paint bucket tag tool.

In the Tags window, click on " ".
You have two options:
"T" pressed + left mouse click : tags the selected surface using currently active tag (Fig. 6.4-A p.7).
"T" pressed + right click : tags the selected surface using currently active tag **without color override**. The only affected vertices are those having the same color picked vertex of a given color, but will stop when meeting another color. See Fig. 6.4-B p.7.

6.4.4   Saving the project

Saving a "project" makes it possible to save all opened selected objects (surface of the cranium and its position, tag arrays etc.) altogether instead of one by one. To save all opened objects, do the following sequence of actions:
1) press "CTRL + A" to select all objects
2) click on "File->Project->Save Project" or on the button "save project" ( ) inside the main window.
3) choose the desired options in the "Save Project" window (see Fig. 6.6 p.9 and the User Guide for further details regarding the available options)
    The advantage of working with projects is that all involved objects (surfaces and their properties) can be reloaded later all at once (and not 1 by 1).

6.5   Acknowledgements

Thanks to the MRI imaging platform for the access to imaging facilities.
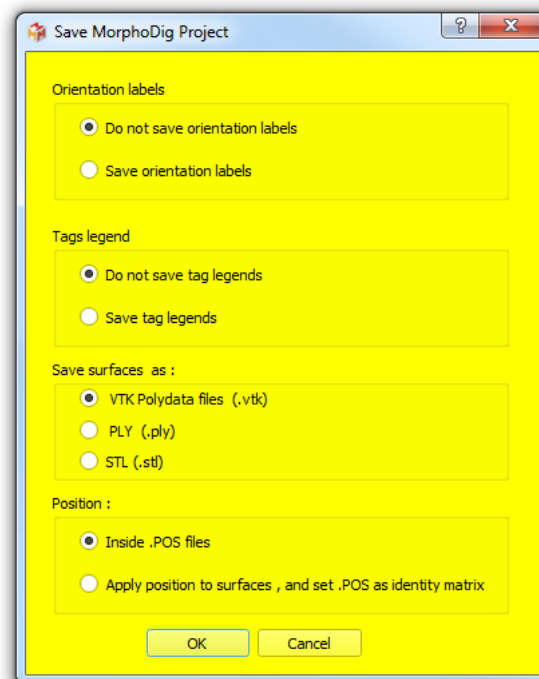
Figure 6.6: Save project window.

References

Lionel Hautier, Cyril Charles, Robert J. Asher, and Stephen J. Gaunt. Ossification sequence and genetic patterning in the mouse axial skeleton. *Journal of Experimental Zoology Part B: Molecular and Developmental Evolution*, 322(8):631–642, dec 2014. ISSN 15525007. doi: 10.1002/jez.b.22590. URL http://doi.wiley.com/10.1002/jez.b.22590.