



NeuroTessMesh Documentation

Version 0.5.6

Juan José García Cantero & Félix de las Pozas Álvarez

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Visualization & Graphics Lab, Universidad Rey Juan Carlos



Visualization
& Graphics Lab

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NEUROTESSMESH INTRODUCTION

NeuroLOTS is a set of libraries and tools that implement a method for generating neuronal meshes and for visualizing them at different levels of detail using GPU-based tessellation. As a part of NeuroLOTS, **NeuroTessMesh** provides a visual environment for the generation of 3D polygonal meshes that approximate the membrane of neuronal cells, from the morphological tracings that describe the morphology of the neurons. The 3D models can be tessellated at different levels of detail, providing either homogeneous or adaptive resolution along the model. The soma shape is recovered from the incomplete information of the tracings, applying a physical deformation model that can be interactively adjusted. The adaptive refinement process performed in the GPU generates meshes that allow good visual quality geometries at an affordable computational cost, both in terms of memory and rendering time. NeuroTessMesh is the front-end GUI to NeuroLOTS framework.

This documentation is for NeuroTessMesh version 0.5.6 software that can be obtained from the homepage.

1.1 Hardware requirements

The application requires a graphic card that supports OpenGL 4.0 at least. NVIDIA offers support for GPU tessellation from the GTX 400 serie on, and ATI/AMD from Radeon HD 5000 serie on. Previous series of both companies are not able to tessellate and consequently the mesh refinement will not work.

Note: The GPU Tessellation on Intel graphics cards is present only on certain models, for more information you can visit the next link: [Supported APIs and Features for Intel Graphics Drivers](#)

1.2 External Links

The homepage for NeuroLOTS and NeuroTessMesh is located at [NeuroLOTS & NeuroTessMesh Homepage](#) and the source code for the latest releases is available in the [NeuroLOTS Github page](#) and [NeuroTessMesh Github page](#). For reporting bugs please use the [NeuroLOTS Github Issues](#) and the [NeuroTessMesh Github Issues](#) pages. If you have any questions or suggestions about NeuroLOTS or NeuroTessMesh refer to dev@vg-lab.es.

1.3 Installation and running

NeuroTessMesh can be downloaded from the [NeuroLOTS & NeuroTessMesh Homepage](#) for Linux and Mac operating systems and executed locally. Additionally it can be executed using a docker image.

1.3.1 Docker containers

The docker containers for **NeuroTessMesh** can be found on [Docker Hub](#). It's recommended to use the highest tag number as it represents the latest official release.

1.3.2 Executing locally

The application options and parameters are:

OPTION	PARAMETER	DESCRIPTION
--version	<i>none</i>	Shows the version of the application.
--help	<i>none</i>	Shows the options and arguments used for executing the application.
-bc	<i>path_to_bc_file</i>	Load BlueConfig file.
-swc	<i>path_to_swc_file</i>	Load SWC file.
-xml	<i>path_to_xml_file</i>	Load XML scene file.
-target	<i>target_label</i>	Specifies target label of the BlueConfig file.
-zeroeq	<i>schema_id</i>	Enables ZeroEQ communications with the specified id.
--json	<i>path_to_json_file</i>	Load JSON data file.
-ws --window-size	<i>width height</i>	Specifies the size of the application window.
-fs --fullscreen	<i>none</i>	Sets the application window to fullscreen mode.
-mw --maximize-window	<i>none</i>	Maximizes the application window to the desktop resolution.
-s --samples	<i>samples_number</i>	Sets the samples number for OpenGL. Overwritten, if present, by the environment variable <code>CONTEXT_OPENGL_SAMPLES</code> .
-nvs --no-vsyc	<i>none</i>	Disables vertical sync for OpenGL. Overwritten, if present, by the environment variable <code>CONTEXT_OPENGL_VSYNC</code> .
-cv --context-version	<i>major minor</i>	Sets the OpenGL version of the application. Overwritten, if present, by the environment variables <code>CONTEXT_OPENGL_MAJOR</code> and <code>CONTEXT_OPENGL_MINOR</code> .

If the options are incompatible or its parameters invalid the application will abort the execution and will show the help message in the console.

1.3.3 Test dataset

A test data for NeuroTessMesh can be downloaded from:

- http://neuromorpho.org/dableFiles/allen%20cell%20types/CNG%20version/H16-03-001-01-09-01_559391771_m.CNG.swc

1.3.4 Docker example

```
1 xhost +local:docker
2 # Pull the image.
3 docker pull vglab/neurotessmesh:0.5.6-nvidia-ubuntu-16.04
4 # Download example data
5 wget http://neuromorpho.org/dableFiles/allen%20cell%20types/CNG%20version/H16-03-001-
   ↪01-09-01_559391771_m.CNG.swc
6 # Run example
7 docker run --gpus 1 -ti --rm -e DISPLAY -v /tmp/.X11-unix:/tmp/.X11-unix -v /etc/
   ↪machine-id:/etc/machine-id -v $(pwd)/H16-03-001-01-09-01_559391771_m.CNG.swc:/H16-
   ↪03-001-01-09-01_559391771_m.CNG.swc --privileged vglab/neurotessmesh:0.5.6-nvidia-
   ↪ubuntu-16.04 /usr/bin/NeuroTessMesh -swc /H16-03-001-01-09-01_559391771_m.CNG.swc
```


NEUROTESSMESH USER INTERFACE

In this section we'll describe the different panels and configuration options in the main dialog.

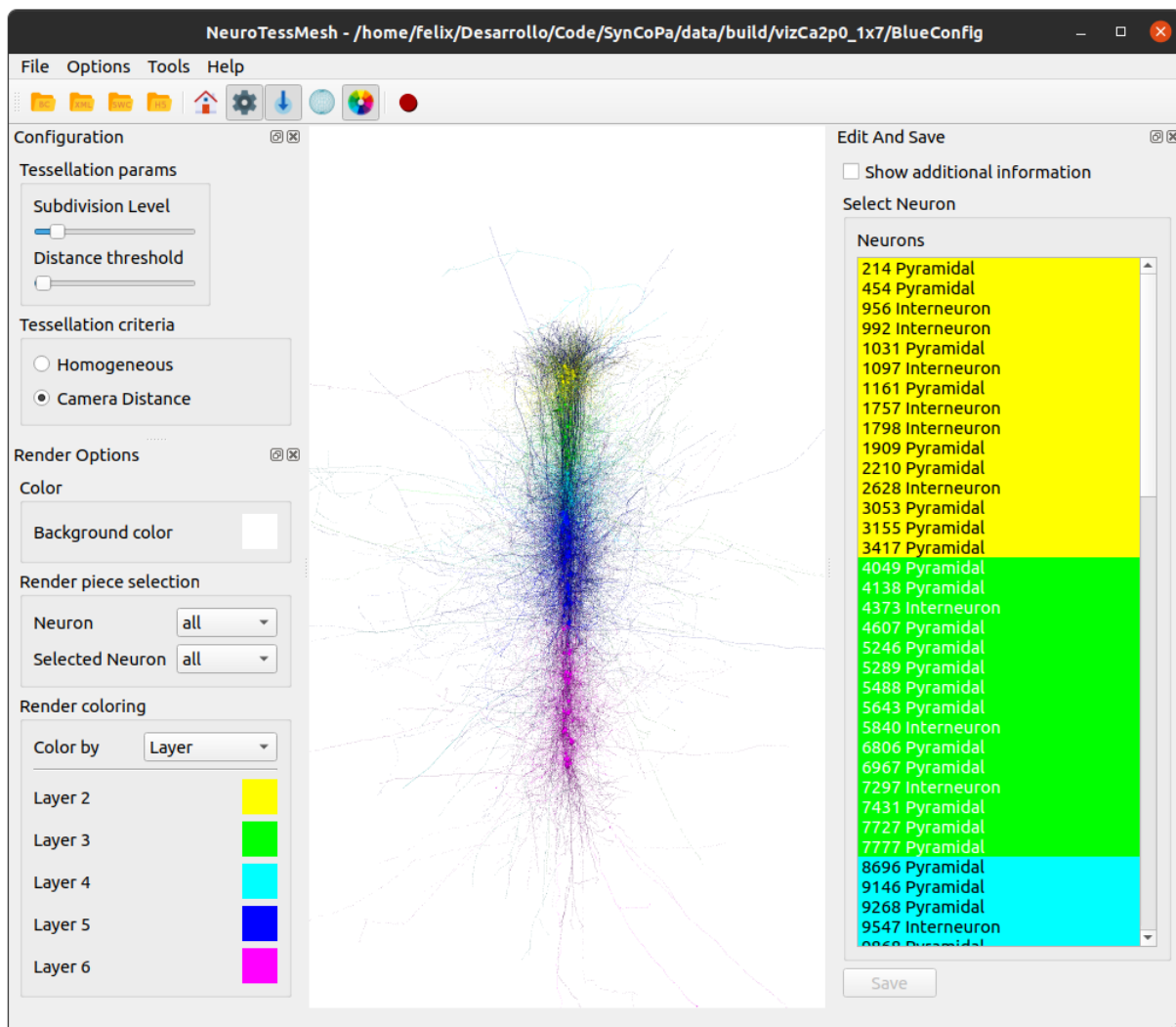


Fig. 2.1: NeuronTessMess application main window.

2.1 NeuroTessMesh Application Toolbar

The application bar presents several icons to perform actions such as opening datasets, and showing or hiding configuration panels. The user can see the menu entries to associate each icon with function (Fig. 2.2).



Fig. 2.2: NeuroTessMesh application tool bar.

2.1.1 File

The first four icons loads an scene or neuron morphology. The neuron morphology must be described following the *SWC format* Scenes composed of severan neurons must be described using an XML specific format (described in the **file formats** section).

- **Open BlueConfig:** Opens neuron morphology in BlueConfig format.
- **Open XML scene:** Opens a scene composed of several neurons.
- **Open SWC:** Opens a neuron morphology in SWC format.
- **Open HDF5:** Opens neuron morphology in HDF5 format.

2.1.2 Configuration

- **Tessellation params:**
 - **Subdivision level:** Maximum level of subdivisions for the visualization. The valid values are in the range of 1 and 30.
 - **Distance threshold:** Further distance to witch the subdivision is applied. The valid values are 0 to 1, 1 being the camera maximum visibility distance.
 - **Tangent smoothing:** Scales the modulus of the orientation vectors applied to smooth the neurite trajectories. The valid values are 0 to 1, 0 being no smoothing and 1 the maximum smoothing.
- **Tessellation criteria:** Select the tessellation criteria applied in the subdivision.
 - **Homogeneous:** Same level of subdivision for all the mesh.
 - **Camera distance:** The level of subdivisions is higher near the camera.

2.1.3 Render panel

- **Color:** Selects the background color for the scene view.
- **Render piece selection:** Select the parts (full, only soma, only neurites) of the neuron to visualize. This selection can be done independently for each of the following types of neurons.
 - **Neuron**
 - **Selected neuron**

The **Selected**, and **Unselected** neurons refer to the entities selected via ZeroEQ selection in other applications.

- **Render coloring:** Selects the coloring method for the current scene. There are four coloring methods:

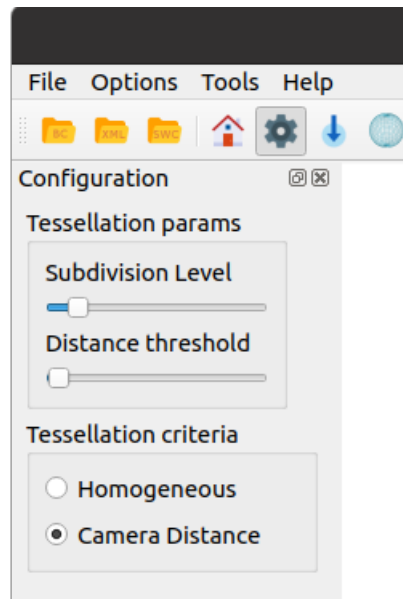


Fig. 2.3: Configuration panel.

- **Selection:** Color neurons by selection.
- **Morphology:** Color neurons by morphology type.
- **Layer:** Color neurons by layer.
- **Function:** Color neurons by function type.

The render coloring method selected will affect the colors shown in the neuron list and edit panel. The color for each possible value can be modified by clicking in the colored box right next to the value name.

2.1.4 Edit and save panel

The **edit and save** panel list the neurons in the scene colored by the selected coloring method in the render panel. The neurons are listed in this panel using the pattern (*id*) (*morphological type*) in its naming.

- **Show additional information:** adds the function and layer information to the neuron name (if available).
- **Select Neuron:** select the target neuron from a list of the neurons in the current scene.
- **Parameters:** different parameters to modify the reconstructed neuronal mesh.
 - **Radius factor:** scales the radius of the initial sphere used to generate the soma. [0-1].
 - **Neurite [n] factor:** factor that multiplies the distance from the neurite n to the soma. 0: Distance=0 (on the soma surface). 1: Current distance*2
- **Save button:** save the actual mesh reconstruction to “obj” file.

2.1.5 Scene camera controls

The camera can be manipulated using the mouse. The movements are:

- **Rotation:** mouse left button + mouse movement.
- **Translation:** mouse scroll button (middle button) + mouse movement.

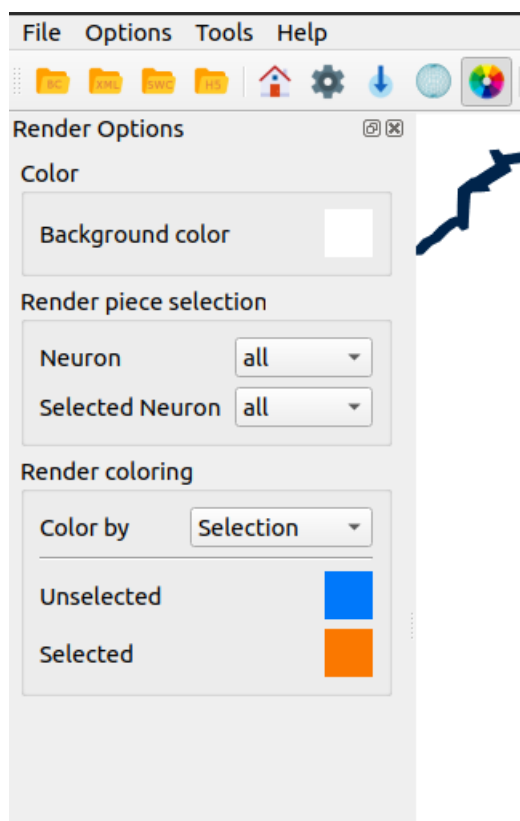


Fig. 2.4: Render panel.

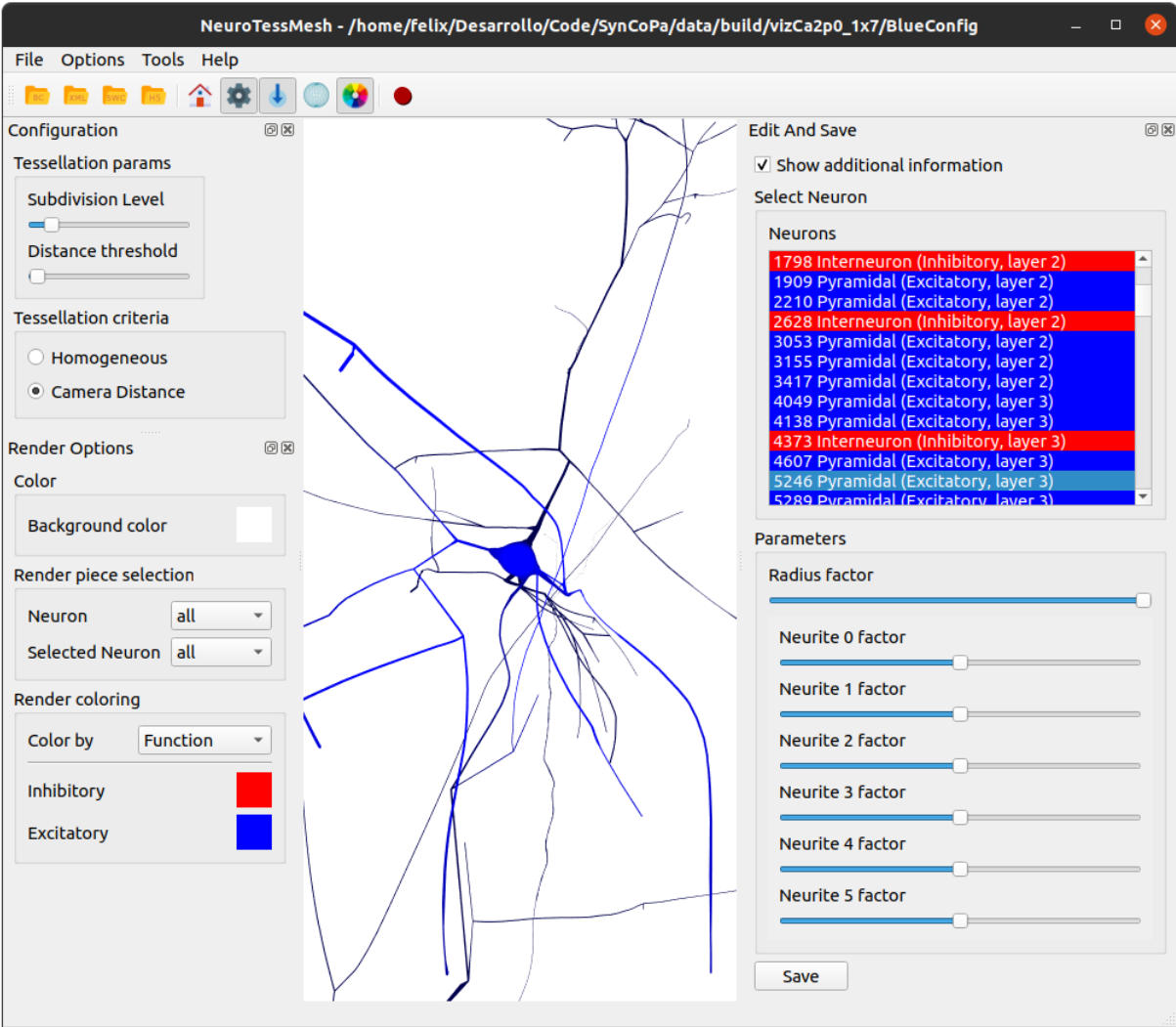


Fig. 2.5: Edit and save panel (left).

- **Zoom:** mouse scroll to zoom in and out.

2.2 NeuroTessMesh Menu Toolbar

2.2.1 File menu

- **Open BlueConfig:** Opens neuron morphology in BlueConfig format.
- **Open XML scene:** Opens a scene composed of several neurons.
- **Open SWC:** Opens a neuron morphology in SWC format.
- **Load camera positions:** Loads a JSON file with the description of camera positions.
- **Save camera positions:** Saves the currently stored camera positions to a JSON file.

2.2.2 Options menu

- **Home:** Reset view perspective to original values of focus and camera distance.
- **Add camera position:** Adds the current camera position to the list of positions with a name given by the user (Fig. 2.6).

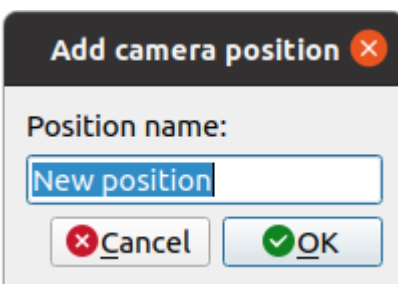


Fig. 2.6: Camera position name dialog.

- **Remove camera position:** Lets the user remove a camera position from the list of positions.
- **Camera positions:** Lists the currently stored camera positions in a submenu. Clicking on a camera position will move the camera to the position.
- **Update on idle:** This will reduce visualization repaint calls to user interaction (camera rotation, etc.) and specific actions.
- **Show FPS on idle update:** Displays a label with current frames per second rate. Note: this might reduce performance due to interface update calls, so it is recommended to hide it when not interested on measuring performance.
- **Render options:** Shows/hides the render panel.
- **Edit And Save:** Shows/hides the edit and save panel.
- **Configuration:** Shows/hides the configuration panel.

2.2.3 Tools menu

- **Recorder:** This button shows the recorder configuration dialog if the recorder is not running. If the recorder is running it will stop the recorder.
- **Advanced recorder options:** This option will enable advanced configuration options in the recorder configuration dialog.
- **Take screenshot:** Takes a screenshot of the 3D view and shows a dialog to resize it before saving the image to disk.

2.3 Recorder

The recording feature can be activated using the **Tools** menu or by clicking the Recorder icon in the toolbar. The user will be presented with the recorder configuration dialog (Fig. 2.7).

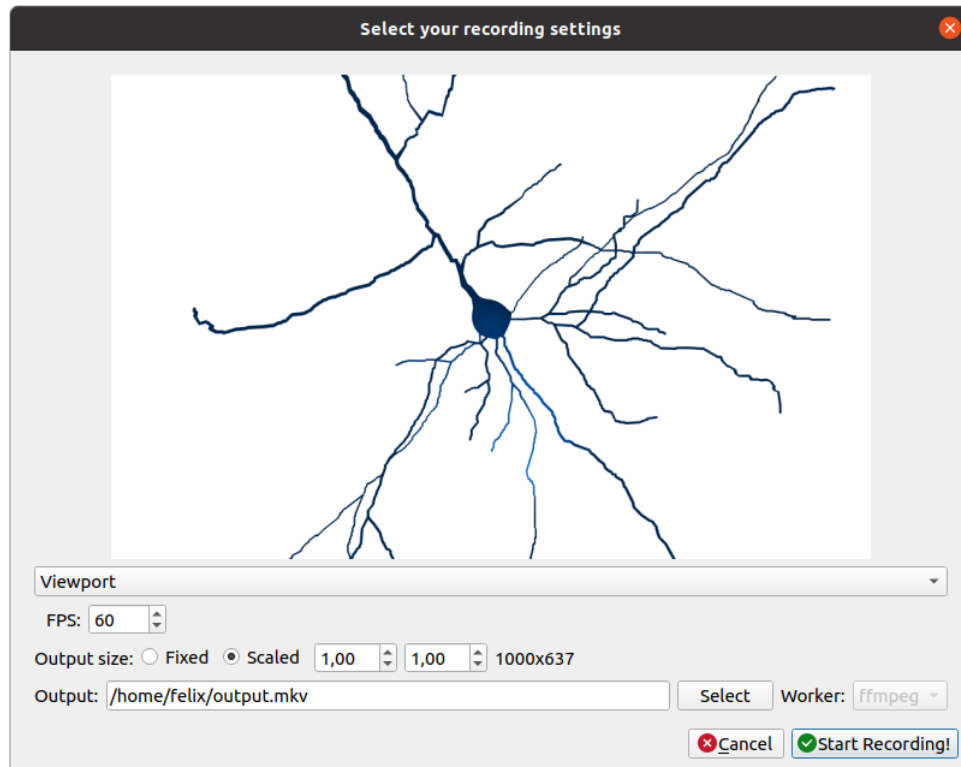


Fig. 2.7: Recorder standard configuration dialog.

The recorder will generate a Matroska MKV video if the media application **ffmpeg** is detected and available, if not the generated output will be individual frames. The frames per second of the output can be specified here. The user can specify the input of the recording, being the main application window or just the 3D viewport.

In the advanced configuration dialog (Fig. 2.8) the user can modify additional options as which worker (video or frames) to use to generate the output. The advanced configuration dialog can be enabled by checking the **Advanced recorder options checkbox** in the **Tools** menu).

Using the advanced configuration an area of the application can be selected for recording as input.

If the output is a video the user can specify the location of the generated file using the Select button. If the output is a sequence of frames the user can specify the destination directory using the Select button in the dialog.

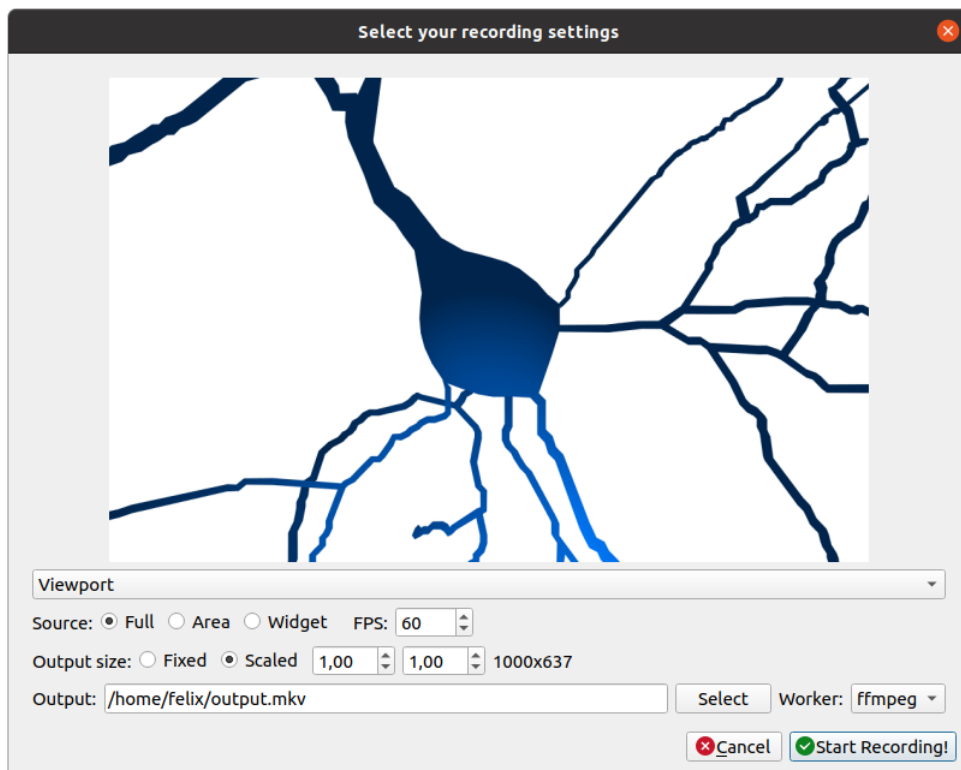


Fig. 2.8: Recorder advanced configuration dialog.

The dimensions of the output are shown and can be modified with the scale options.

While the recorder is working the associated toolbar button will remain down and the icon will change every second with an image of a “Stop” button with REC letters written inside it. The user must click it again to stop the recording. The recorder can also be stopped using the **Recorder** button in the **Tools** menu or the keyboard shortcut **Ctrl + R**.

Note: If the output is a video the filename of the output file will end with “_temporal” while recording. Once the recording has finished it will change to the selected output name in the configuration dialog. The application will warn if the user tries to exit the application while a recording is being made.

Warning: To record a video the system must have **ffmpeg** installed, preferably with Nvidia hardware acceleration. If **ffmpeg** is not available in the system only the **images** worker will be available in the recorder. In Windows OS it is necessary to put the **ffmpeg** executable in the same directory of the NeuroTessMesh executable.

2.4 Take screenshot

Using the **Take screenshot** action either from the menu or by using the toolbar icon will display the captured image in the resize dialog (Fig. 2.9). The minimum size of width and height is one hundred pixels. The image will be resized to the selected resolution before showing a save dialog.

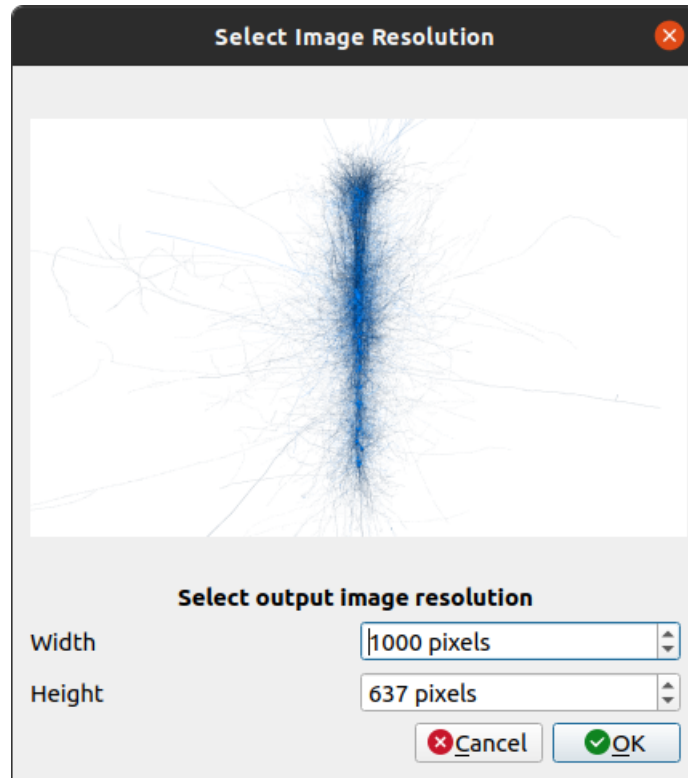


Fig. 2.9: Resize image dialog.

2.5 Keys and shortcuts

- **Open BlueConfig:** Ctrl + Shift + B
- **Open XML Scene:** Ctrl + Shift + X
- **Open SWC:** Ctrl + Shift + S
- **Exit application:** Ctrl + Shift + Q
- **Home (reset view):** Ctrl + H
- **Update on idle:** Ctrl + I
- **Show FPS on idle update:** Ctrl + S
- **Show wireframe:** Ctrl + W
- **Render options:** Ctrl + B
- **Edit and save:** Ctrl + M
- **Configuration:** Ctrl + C
- **Toggle Recorder:** Ctrl + R

RUNBOOK

Note: This runbook will test the main functionalities of NeuroTessMesh and can be considered as a basic tutorial for the application, but **not** as a complete and exhaustive tutorial of all its functionalities. This runbook is up to date with NeuroTessMesh version 0.5.6.

1. Load a “swc” file (Fig. 3.1).

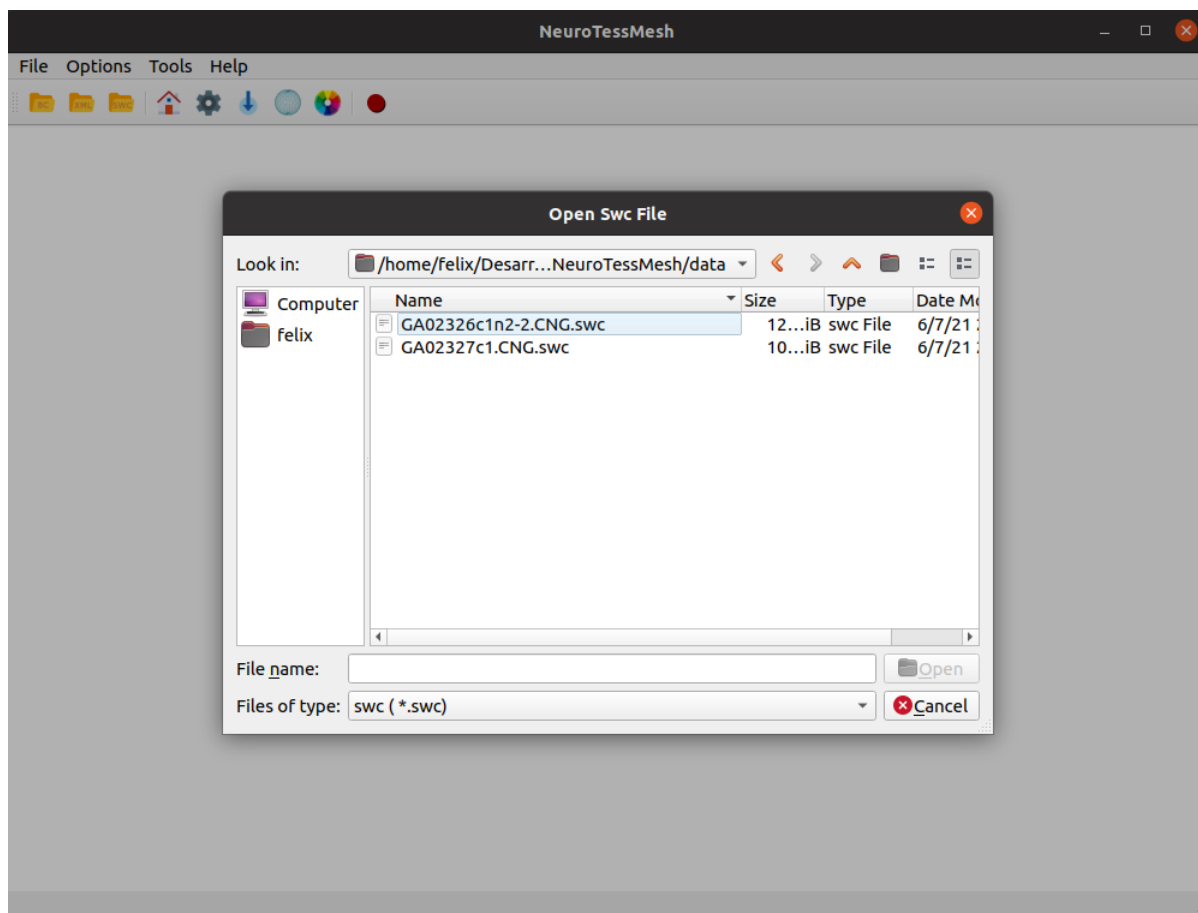


Fig. 3.1: Opening a file.

2. Visualize and navigate through the reconstructed neuronal mesh using the scene camera controls as previously explained in user interface section (Fig. 3.2).

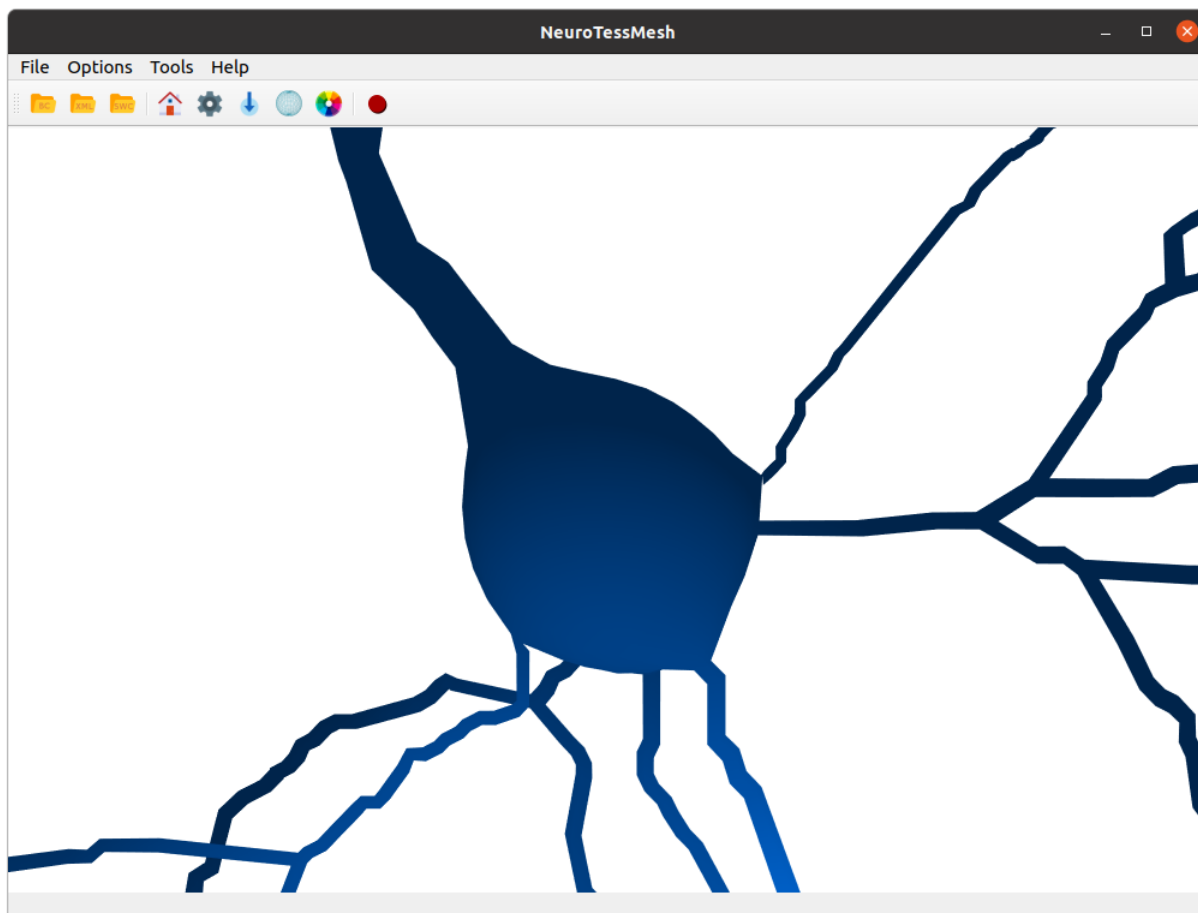


Fig. 3.2: 3D View navigation.

3. Change the render options. In this example the Subdivision level has been increased to 10, the Distance threshold has been also increased and the Tessellation criteria has been modified to Homogeneous criteria (Fig. 3.3).

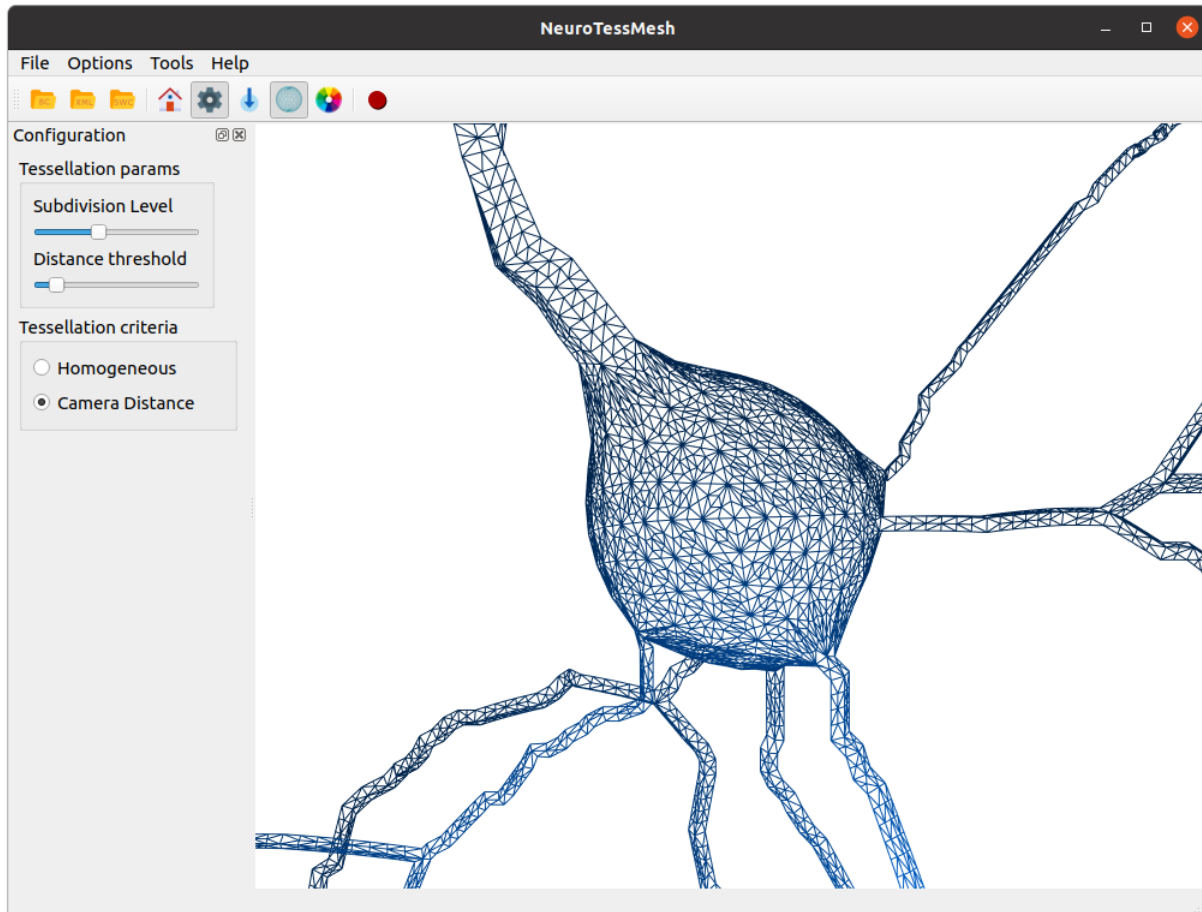


Fig. 3.3: Render options manipulation.

4. Modify the soma reconstruction params. In this example the soma volume has been decreased setting the Radius factor to 0.75 and the starting points of the neurites have been displaced using the Neurite [n] factors (Fig. 3.4).

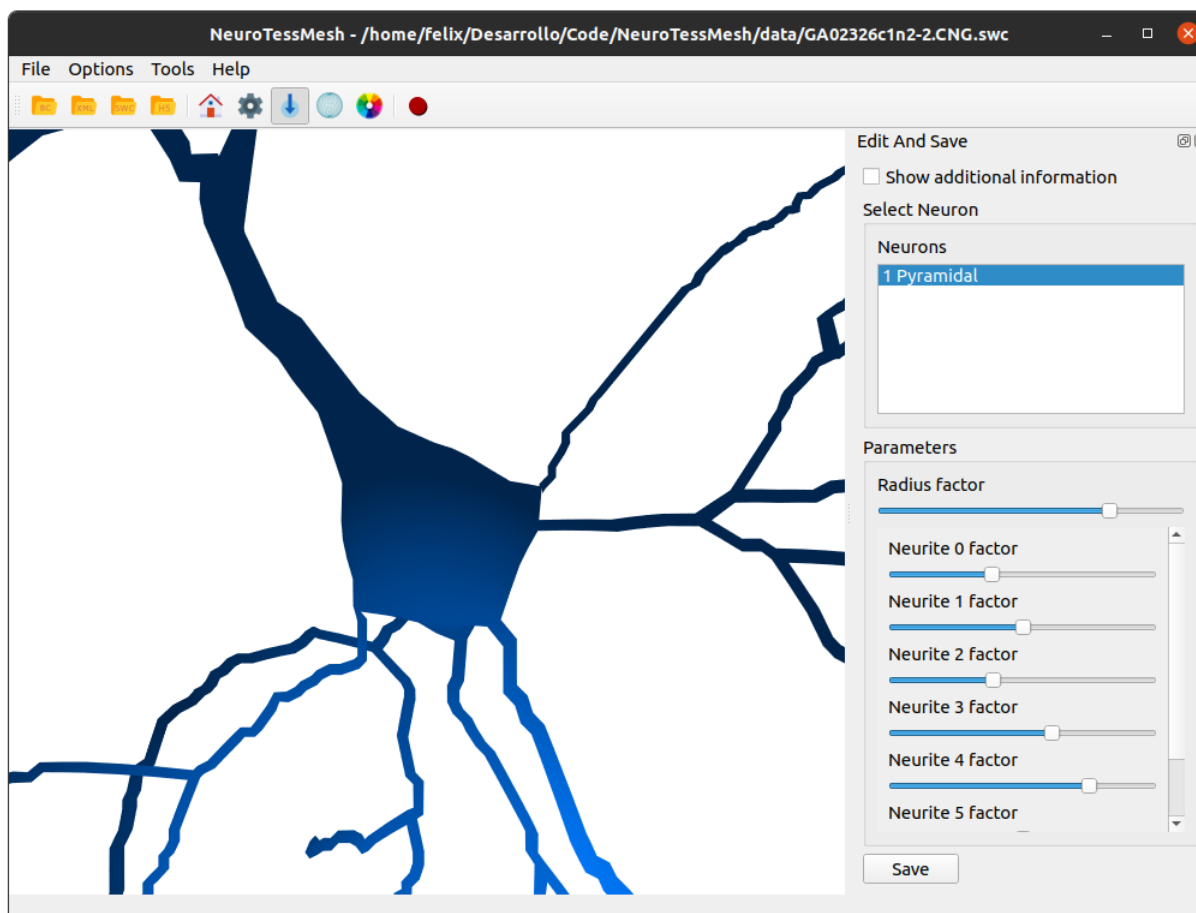


Fig. 3.4: Reconstruction parameters manipulation.

5. Save the results to a “obj” file (Fig. 3.5).

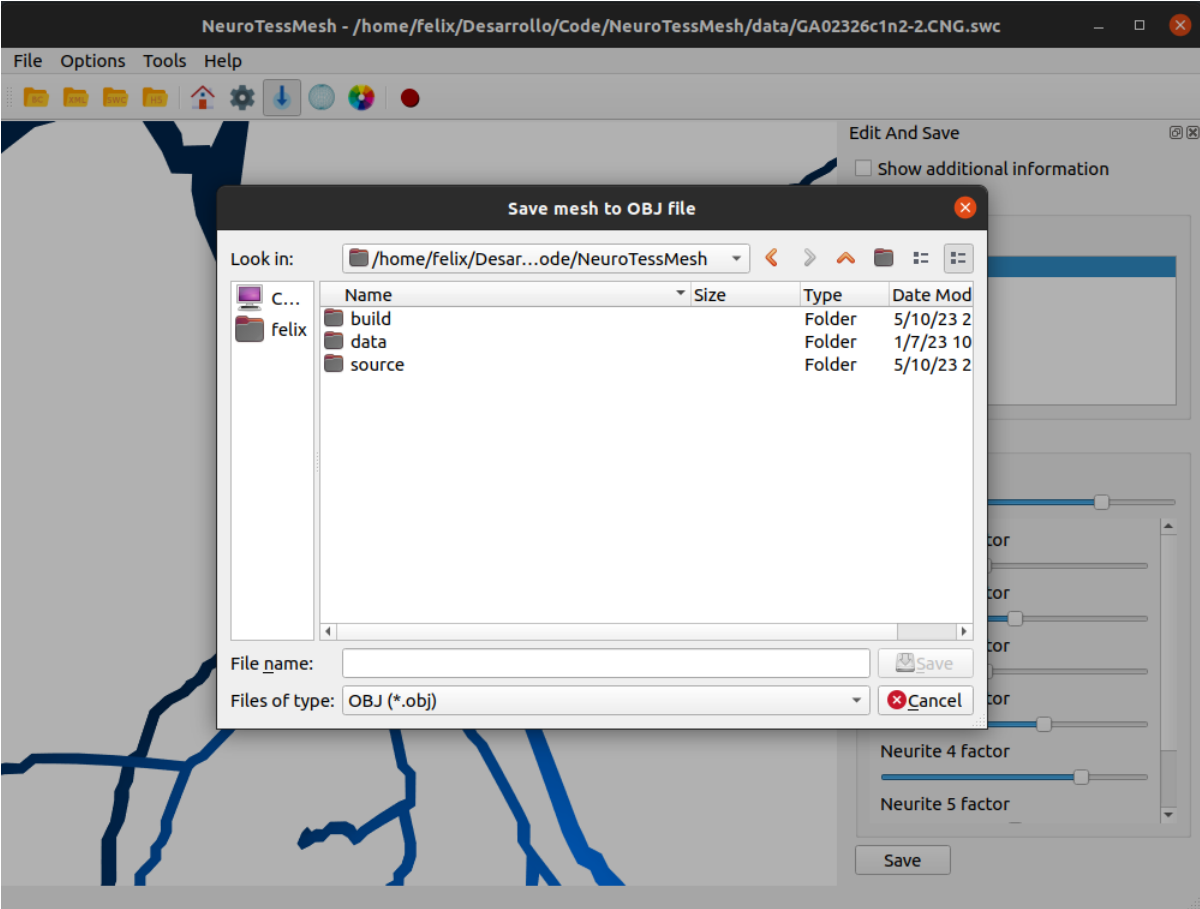


Fig. 3.5: Save results to file.

NEUROTESSMESH FILE FORMATS

This section describes the format of the XML file used to describe a scene composed of several neurons.

4.1 XML Scene file

Note: Work in progress.

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