

# AMAAZE Meshlab Plugin Documentation

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This documentation describes the [AMAAZE](#) Meshlab plugins.

## 1 Virtual Goniometer

The Meshlab Virtual Goniometer plugin can be used to take angle measurements on triangulated meshes. Each section below describes basic features of Meshlab and the plugin. For more details on the plugin, see our paper [1].

### 1.1 Installing the Virtual Goniometer plugin in Meshlab

The Virtual Goniometer is an additional plugin that can be loaded into Meshlab (provided you have the most recent version of Meshlab). Windows, MacOS, and Linux are supported. The instructions below detail how to install the latest version of Meshlab and load the Virtual Goniometer Plugin.

First, make sure to uninstall any versions of Meshlab you currently have installed. On Windows, you will also need to delete the folder `c://users/username/AppData/VCG` to make sure any plugins you previously installed are removed. Then download and install the new (May 2021) release of Meshlab [here](#), and download the Meshlab Extra plugins from [here](#). Note there are two versions of the plugins, depending on whether you installed the single or double precision version of Meshlab. Meshlab should warn you if you try to use the wrong version.

Unzip the extra plugins to a known location on your computer, open Meshlab, click on the menu item `Help->Plugin Info`, and then `Load Plugins`. Navigate to the folder where you extracted the plugins and select the Virtual Goniometer plugin (the name is slightly different in each operating system). Then click `OK`. Figure 1 shows how the Plugin Information box should appear after the Virtual Goniometer Plugin is loaded successfully.

It may be necessary to bypass some operating system security settings to allow the plugin to be loaded. In particular, if the plugin is blocked in MacOS, go to the operating system settings under `Settings ->Security and Privacy ->General` where you should see a prompt about the plugin, which you can manually allow. The plugin need only be loaded once, and then your version of Meshlab will always have the plugin installed.

### 1.2 Loading a mesh

Load a mesh into Meshlab with `File->Import Mesh`.

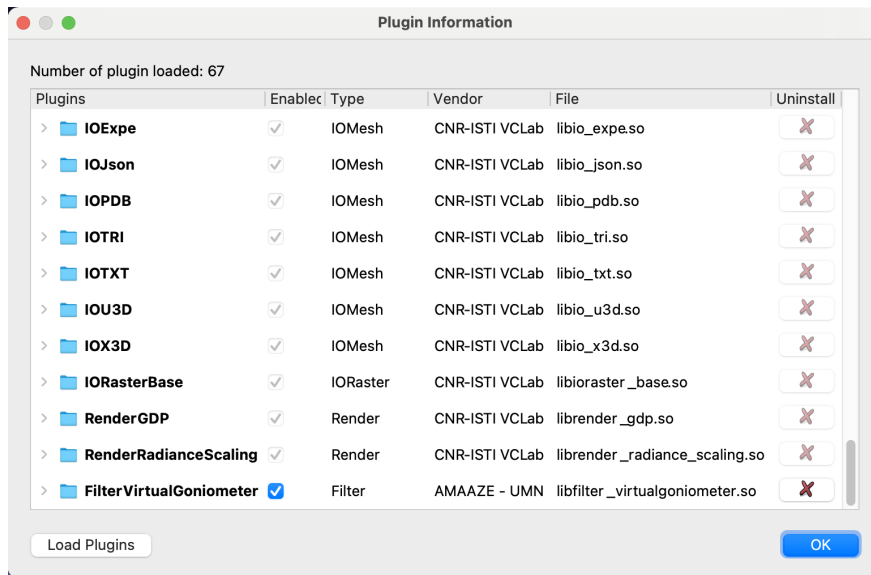


Figure 1: Plugin Information Dialog Box.

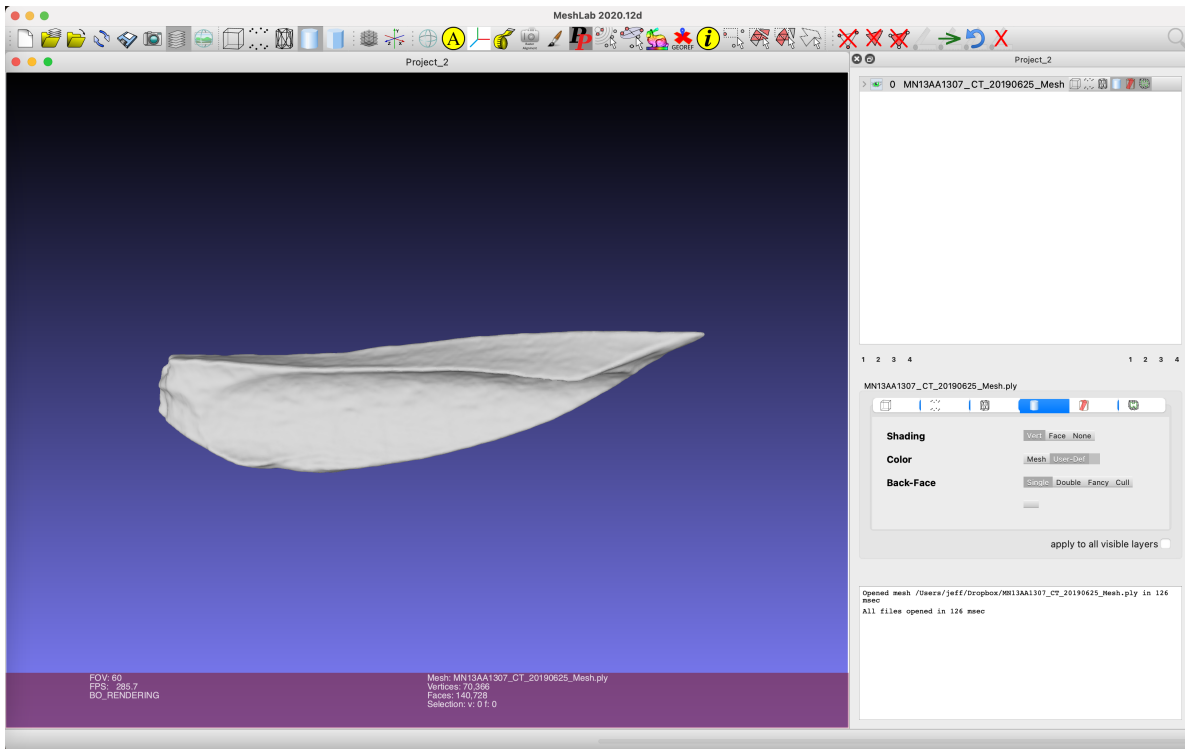



Figure 2: Meshlab after loading the plugin and a bone mesh. Notice the Virtual Goniometer buttons on the top right of the tool bar.

### 1.3 Selecting a patch on the mesh

In most modes of operation, the user must select some part of the mesh to run the virtual goniometer on. This can be done with any selection mechanism in the **Edit** menu. One of the most useful is **Edit->Select Vertex Clusters**, which allows the user to click on a point on the mesh and drag the mouse to choose the radius of the patch. As a shortcut, **Edit->Select Vertex Clusters** can be accessed by clicking on the button  on the toolbar at the top of the screen in Meshlab.


### 1.4 Output CSV file

All angle measurements taken in the plugin are recorded in a CSV file

`VirtualGoniometer_Measurements.csv`

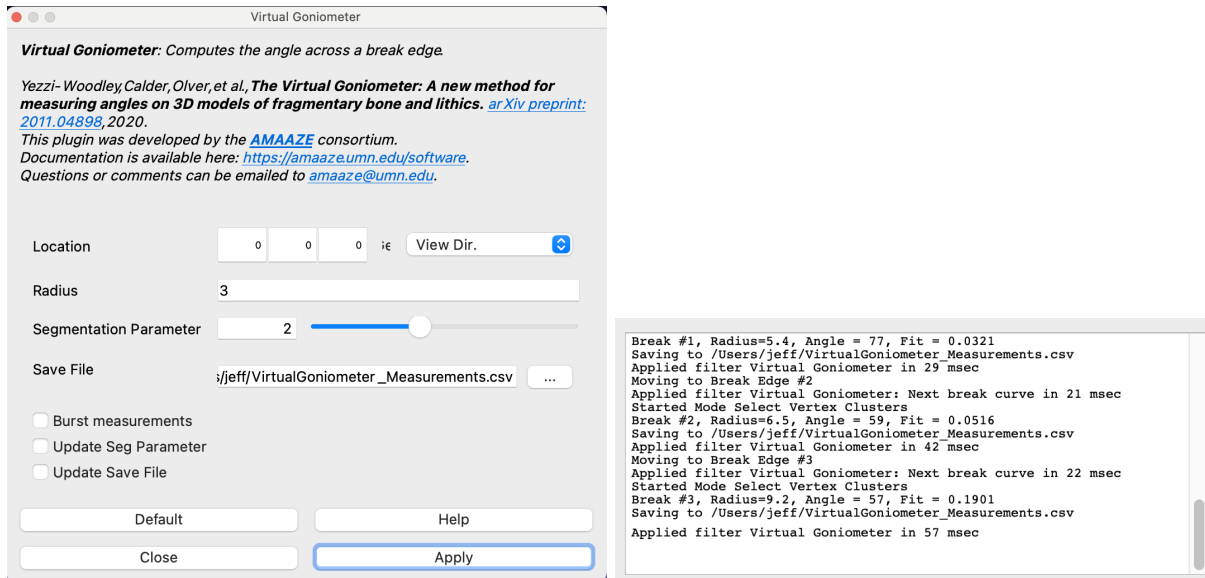
stored in the user's home directory. The location and name of the CSV file can be modified in the dialog box, as described in the section on "Single vertex selection" below. The file contains a lot of information about the measurements, including the mesh name, date and time the measurement was taken, break # and measurement #, colors used to indicated clustering, angle, radius of the patch, number of vertices in the patch, center point of the patch, the PCA goodness of fit, and the segmentation parameter used. The CSV file is also actively used by the plugin to load measurements from, and to undo measurements. It is generally a good idea to refrain from directly editing the CSV file, since it may lead to unpredictable behavior of the plugin. Measurements can be deleted through the plugin with the **undo** button, as described below. If direct editing is required, it is suggested to make copy of the CSV file and edit the copy.

### 1.5 Measuring an angle

The Virtual Goniometer plugin can be executed in three different ways: (1) Through the **Quality** menu under **Filter->Quality Measures and Computations->Virtual Goniometer**, (2) clicking the button  on the right side of the toolbar at the top of the screen, or (3) using the keyboard shortcut **Ctrl+Shift+V**. The behavior of the plugin depends on the current selection the user has made, and is split into two cases.

- **Patch selection:** If the user selects a patch with at least 10 vertices, as described above, then the plugin runs the virtual goniometer on the patch, colorizes the clustering of the patch on the mesh, and reports the break angle to the Meshlab log and records the measurement in the CSV file.
- **Single vertex selection:** If the user selects only a single vertex (or less than 10 vertices), then the plugin will open a dialog box (see Figure 3) requesting the user enter the  $(x, y, z)$  coordinates and a radius  $r$  for the measurement. The box also has a segmentation parameter the user can change, and options to take a burst measurement, or to only change the segmentation parameter without taking a measurement. If the user selected at least 1 vertex (and less than 10), then the  $(x, y, z)$  coordinates in the dialog box are populated with the coordinates of one of the selected vertices (the first one encountered looping over the mesh).

If the user checks the box **Burst Measurements** before clicking **Apply**, then the provided radius value is ignored, and the plugin takes 20 measurements at a series of increasing radii, starting from the smallest radius that includes 20 vertices, up to the smallest radius that includes 0.5% of the vertices in the mesh. The patch corresponding to the largest radius is colored on the



(a) Menu

(b) Log

Figure 3: Virtual Goniometer menu and log.

mesh. All 20 measurements are recorded in the CSV file, but the burst is treated as a single measurement for the undo operation described below.

If the user checks the box **Update Parameter Only**, then upon clicking **Apply**, the plugin will update the segmentation parameter to the one selected by the user with the slider bar. This will be set for all future measurements until changed again by the user, or until Meshlab is restarted. Please see our paper [1] for details on the segmentation parameter. The default value of 2 is good for most purposes.

If the user checks the box **Update Save File**, then upon clicking **Apply**, the plugin will update the CSV filename and path with the file chosen in the dialog box under **Save File**. It is ok to select an existing file, in which case the measurements are appended to the file (you can safely ignore the warning about overwriting the file).

**Note:** If the patch is not colorized (as in Figure 5) after taking a measurement, you may need to change the mesh coloring option to **vert**. This is an option in the right panel in Meshlab, see Figure 4.

## 1.6 Next break curve ➡

The plugin has a feature to allow the user to take measurements along different break curves, and record the break curve number along with the angle measurement. By default, the virtual goniometer starts on break curve #1. After taking possibly several different measurements along break #1, the user can advance to break #2 by clicking the button ➡ on the toolbar, using the shortcut **Ctrl+Shift+N**, or accessing the option through the **Filter->Quality...** menu. This advances the internal break # variable in the Virtual Goniometer, and reports this to the Meshlab log. All future measurements will be for break #2, and will be colored differently on the mesh. After advancing to a new break curve, the colorized patches from previous breaks are grayed out slightly to indicate they are not active break curves. Figure 5 shows the result of taking many

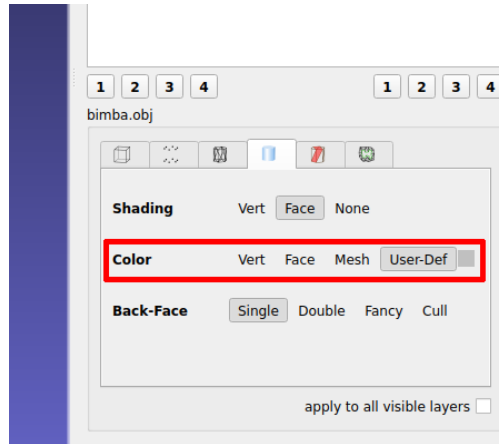


Figure 4: To see the colorization of each measurement patch, it may be necessary to set the mesh coloring to vert, instead of the default user-def.

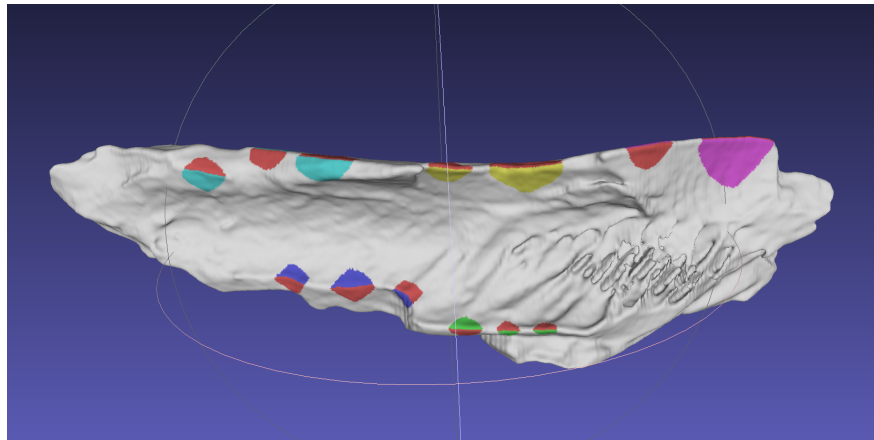


Figure 5: Meshlab virtual goniometer after taking several measurements along different break curves.

different measurements along different break curves, and Table 1 shows the pairs of colors used for each break #.

### 1.7 Undo a measurement ↺

The plugin has an **undo** feature, which is run via the button ↺, the shortcut key **Ctrl+Shift+U**, or the menu. Unlimited undo operations are allowed. Beware that the corresponding angle measurements will be deleted from the CSV file. Thus, **undo** can be used to remove undesired measurement sessions from the CSV file without editing it directly. The user can also undo advances of the break # variable, to return to a previous break curve and take additional measurements. There is no **redo** feature.


### 1.8 Resetting and loading ✖


The reset button ✖ clears all measurements from the mesh and initializes the plugin to the state it was in when Meshlab was first opened. It does not delete measurements from the CSV file. It may sometimes be necessary to reset the Virtual Goniometer when loading new meshes in Meshlab. The

Break #	Color 1	Color 2
1	Red	Blue
2	Red	Green
3	Red	Magenta
4	Red	Yellow
5	Red	Cyan
6	Red	Black
7	Blue	Green
8	Blue	Magenta
9	Blue	Yellow
10	Blue	Cyan
11	Blue	Black
12	Green	Magenta
13	Green	Yellow
14	Green	Cyan
15	Green	Black
16	Magenta	Yellow
17	Magenta	Cyan
18	Magenta	Black
19	Yellow	Cyan
20	Yellow	Black
21	Cyan	Black

Table 1: Color codes for each break #.

plugin does not know when the user closes a mesh and opens a new one. It tries to monitor the name of the mesh and performs an automatic reset when it changes, but to be safe, it is best to either start a fresh copy of Meshlab for each mesh that is measured, or to reset the Virtual Goniometer for each new mesh. This is important to make sure the **undo** and **break #** features work correctly.

When the reset button  is pressed, a dialog box opens with an option to check a box to **Load from CSV file**. If the user checks this box, then the plugin will reset the Virtual Goniometer, and then look through the CSV file for measurements matching the mesh that is currently open. If measurements are found, they are loaded and displayed on the mesh as though they were just taken by the user. The measurements are also moved to the end of the CSV file. This allows the user to resume a previous measurement session, and to add additional measurements to, or undo measurements from, that session.

Sometimes the CSV file may have more than one session for a given mesh. A session is defined as all the measurements taken between when the user loads the mesh and when they close Meshlab or reset the Virtual Goniometer. The sessions are recorded with a measurement # that resets to 1 at the start of each session. The **Load** feature loads the first session encountered in the CSV file. Since the loaded measurements are moved to the end of the CSV file, the user can keep clicking  to cycle through measurement sessions. To delete a measurement session, simply load it and undo all the measurements.

## References

- [1] K. Yezzi-Woodley, J. Calder, P. J. Olver, A. Melton, P. Cody, T. Huffstutler, A. Terwilliger, G. Tostevin, M. Tappen, and R. Coil. The virtual goniometer: A new method for measuring angles on 3D models of fragmentary bone and lithics. *Archaeological and Anthropological Sciences*, 13(106), 2021.