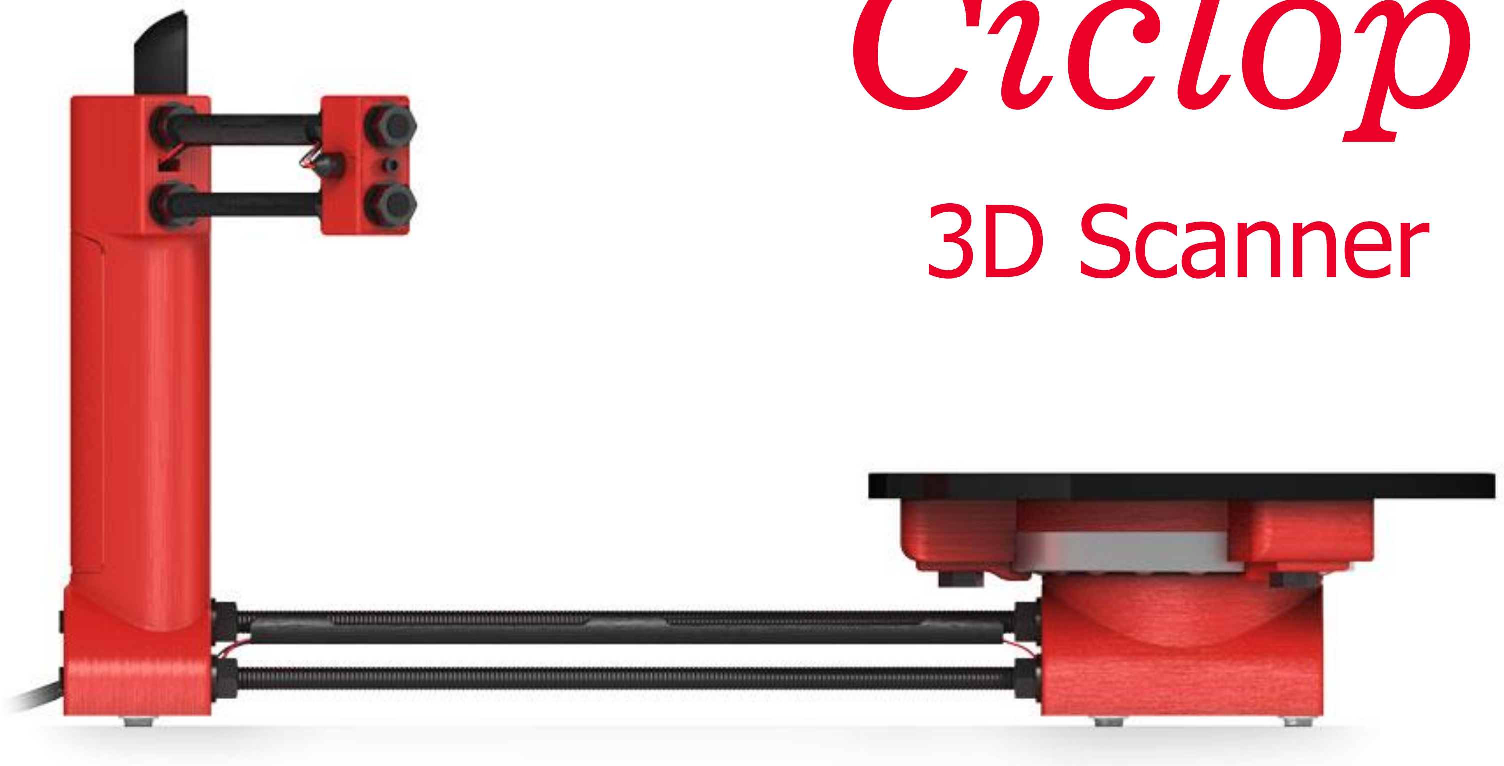
Ciclop

3D Scanner

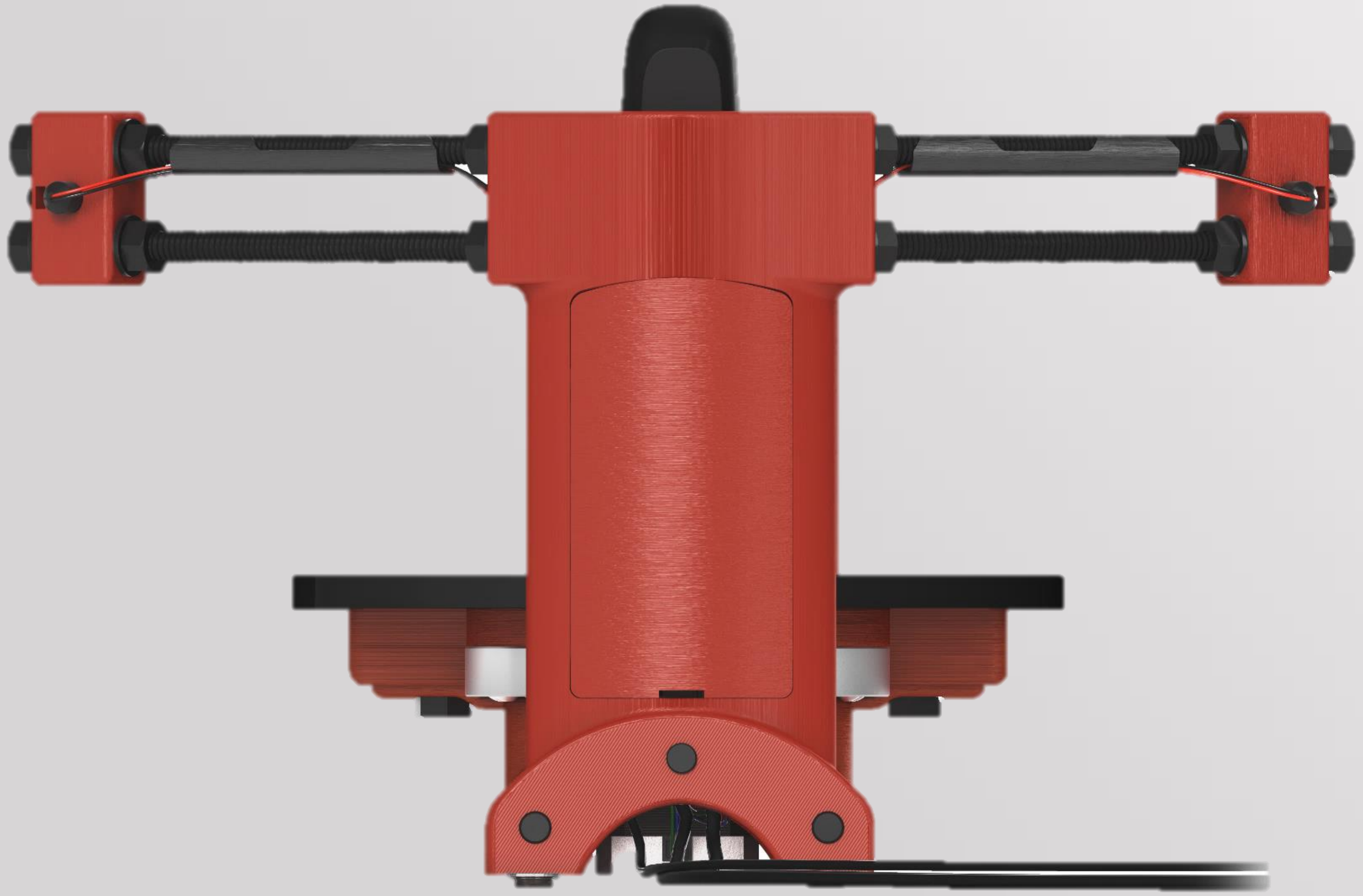


What is Ciclop?

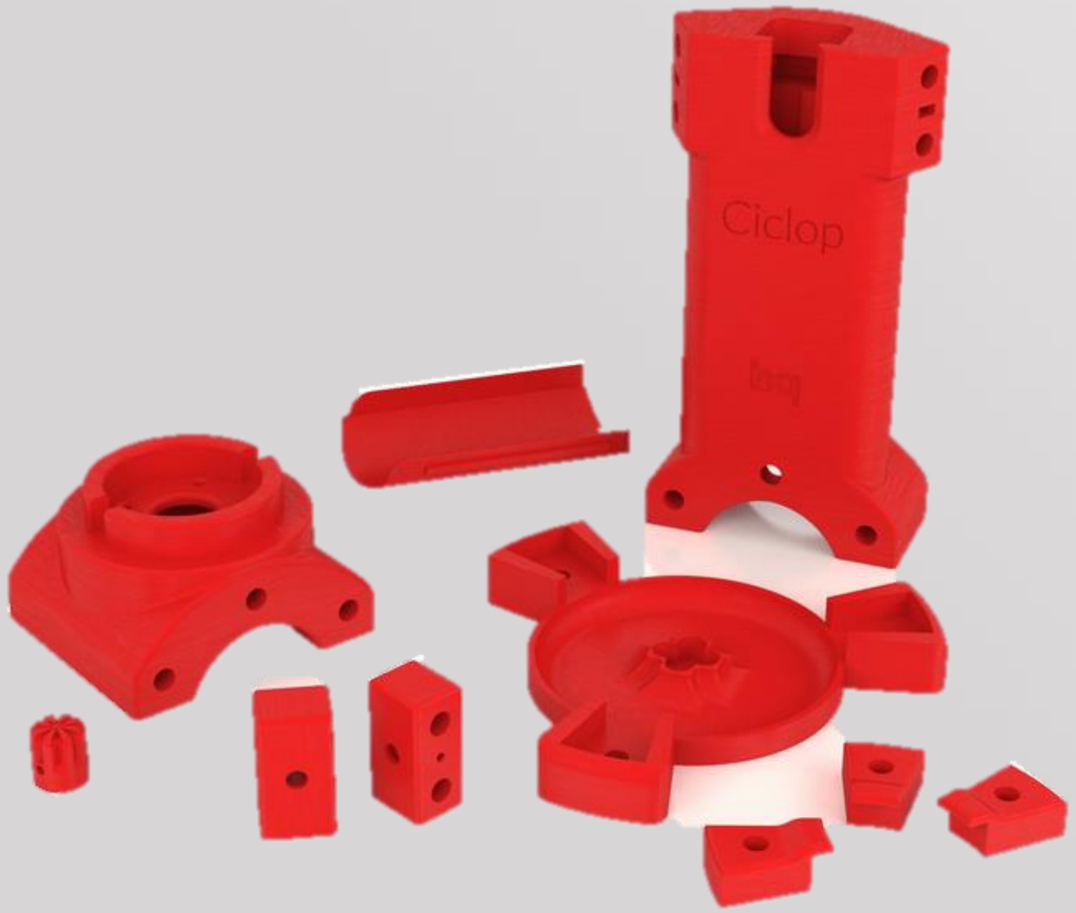
- First DIY 3D Scanner
- Fully customizable
- 30 minutes assembling
- Open-Source

What is Ciclop?

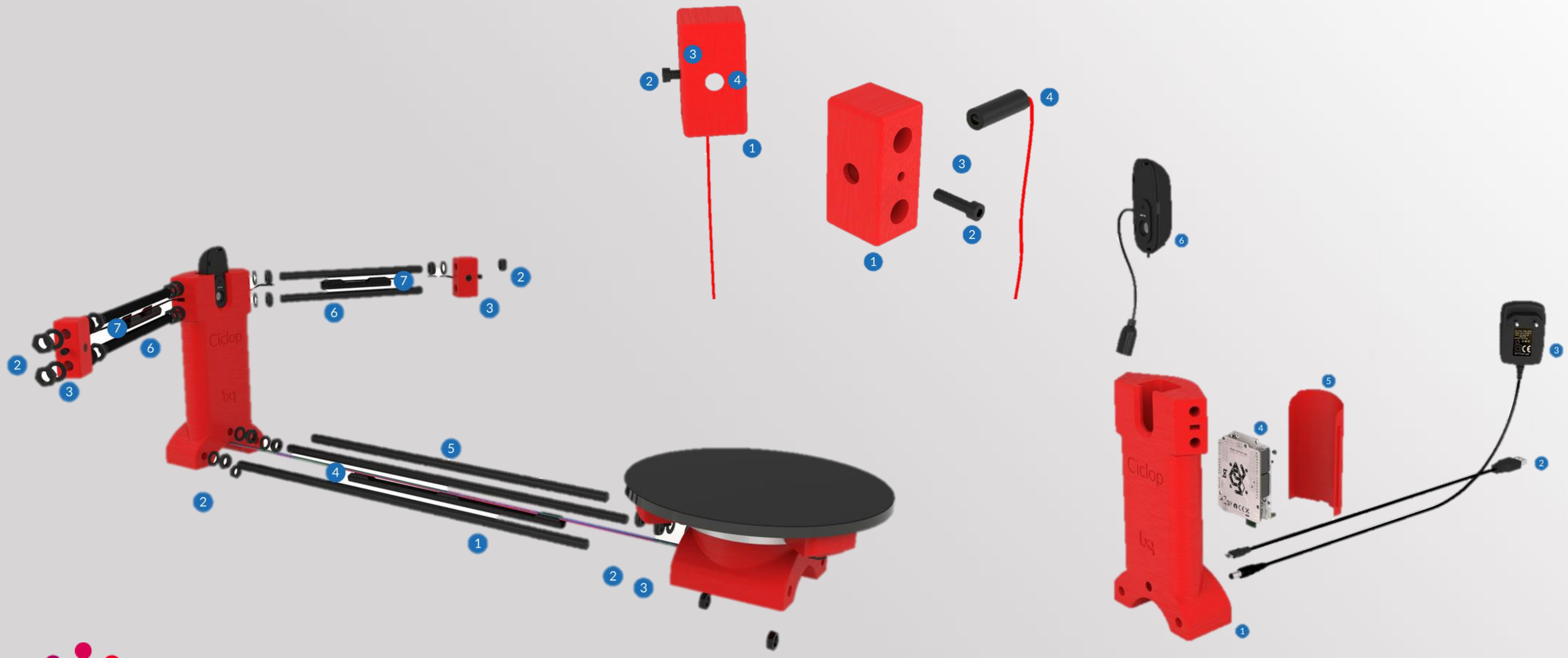
- Scanning volume: 20 cm (diameter) x 20 cm (height)
- Accuracy around 0,5mm (according to calibration)
- BQ ZUM BT-328 & ZUM Scan
- Ready to connect 2 motors, 4 lasers, or one LDR.



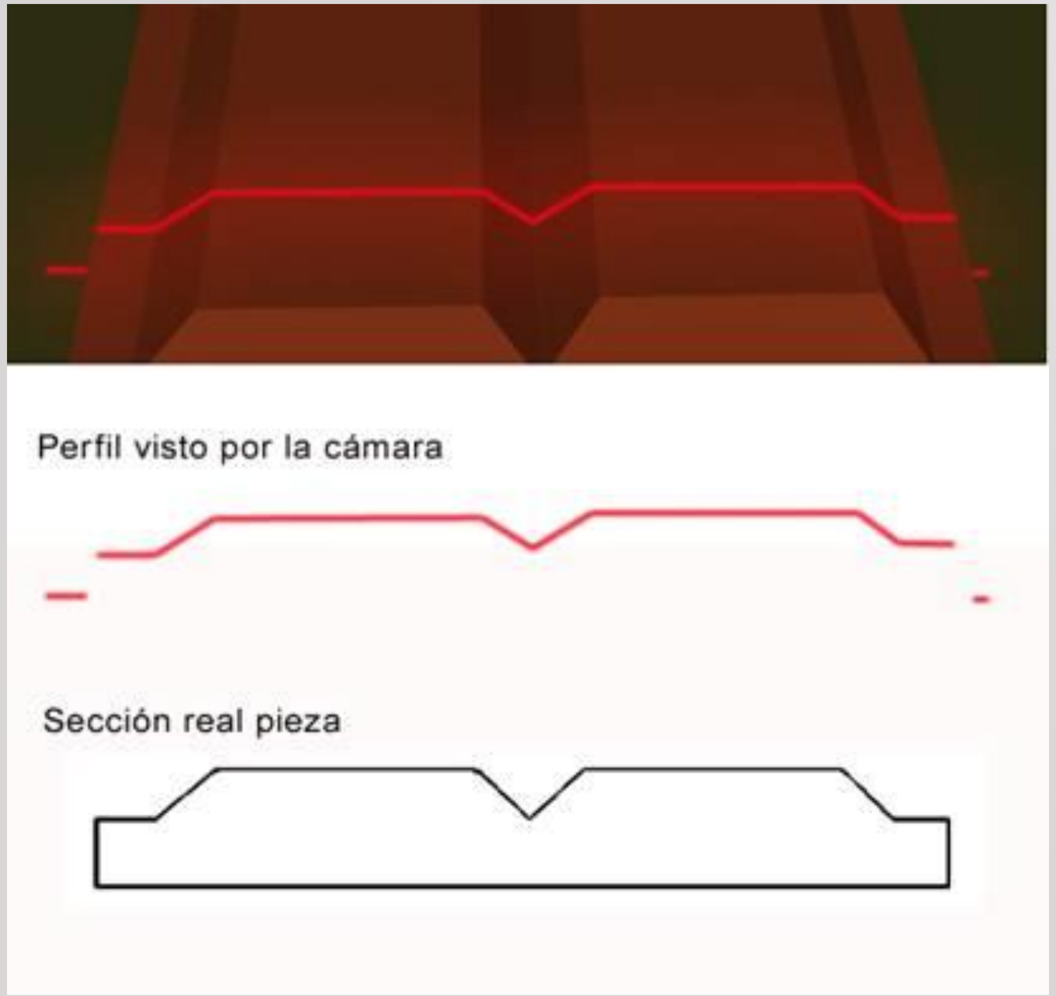
Hardware: Easy to build and open to improve



The technology: Laser triangulation



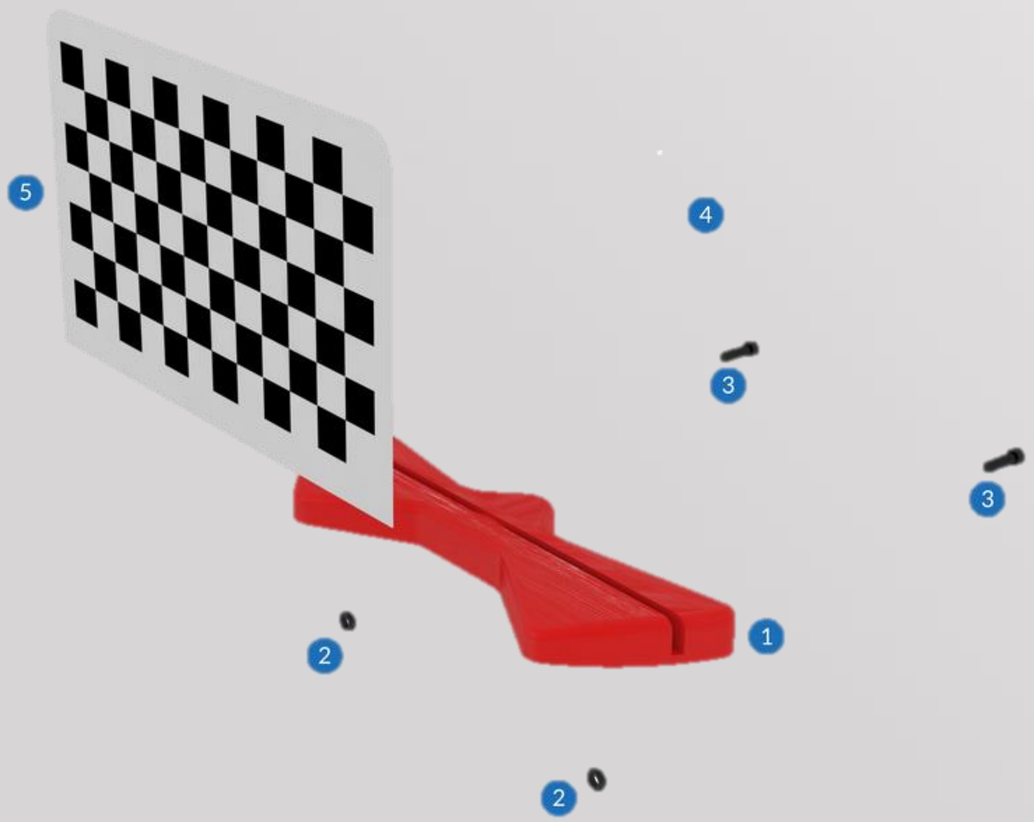
The technology: Laser triangulation



Lasers impact on the rotating piece

The camera collects the surface information, analyzes and recreates the figure

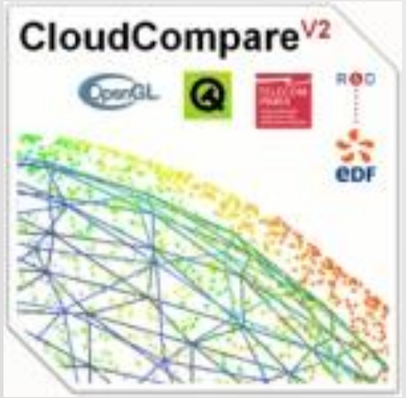
Auto-calibration: A differential value



Software: Open to the future

- HORU
  S
- Camera Drivers
- Reconstructi
  on software

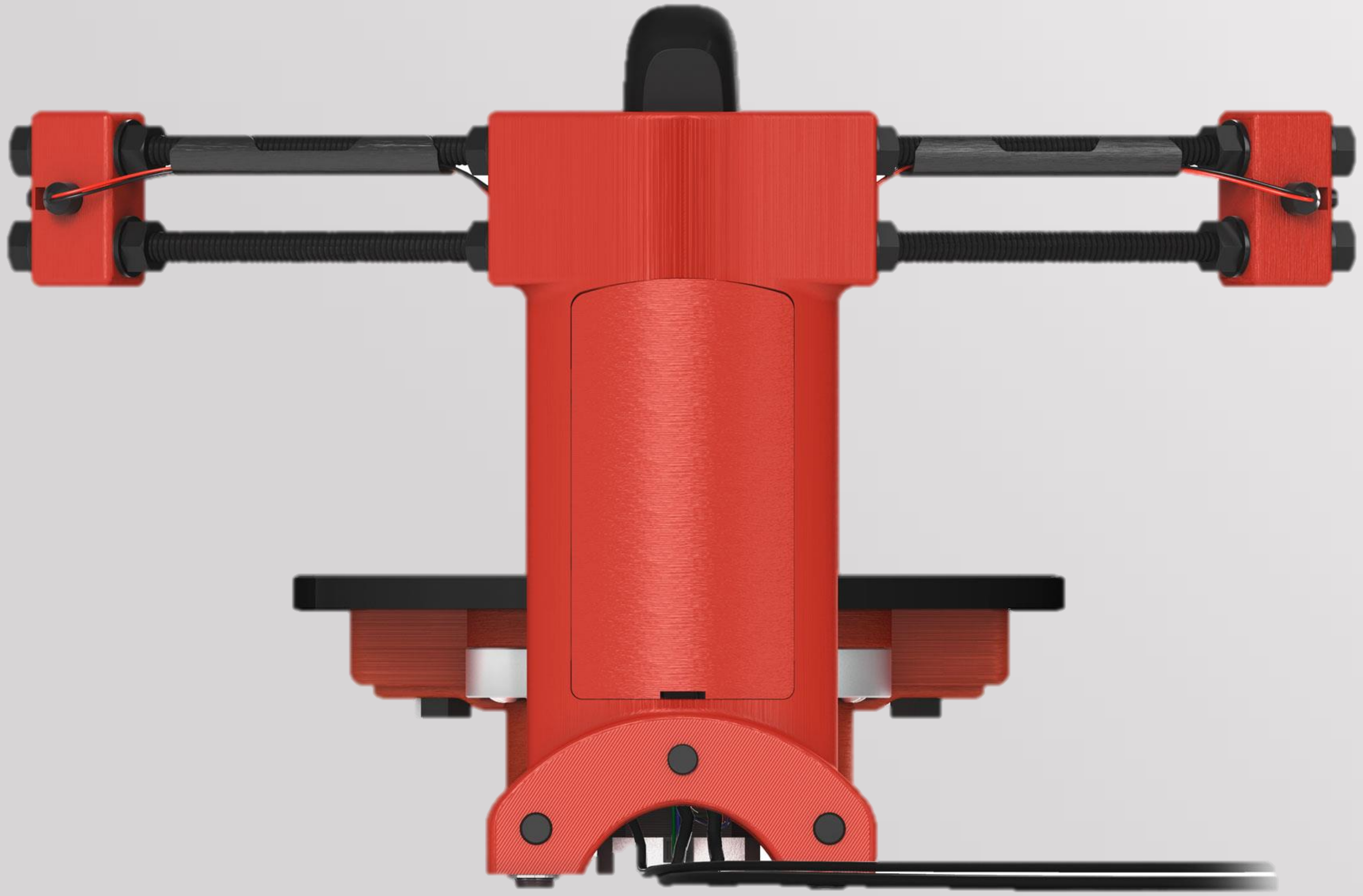
Meshlab



CloudCompa
re

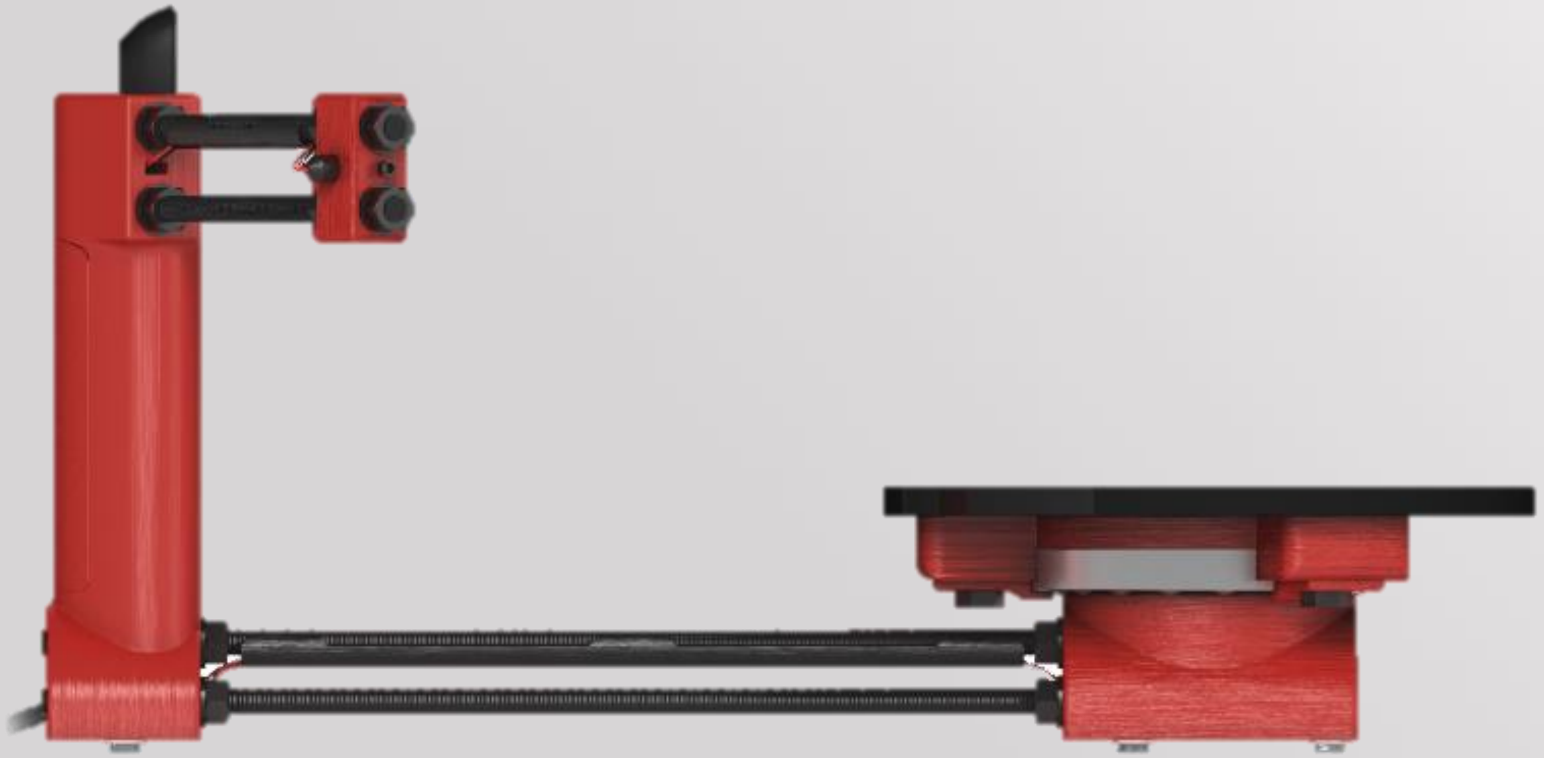
How can I obtain a good scanning?

Many factors are involved in the process: Lighting, color of the piece, brightness...Here we will learn how to control them



Ambient Lighting

Lighting should be uniform, indirect and medium intensity. Thus, the appearance of reflections and shadows are avoided.



Ambient Lighting

A commendable idea is to set a direct light from the back, with some dispersion and not concentrated

Object material

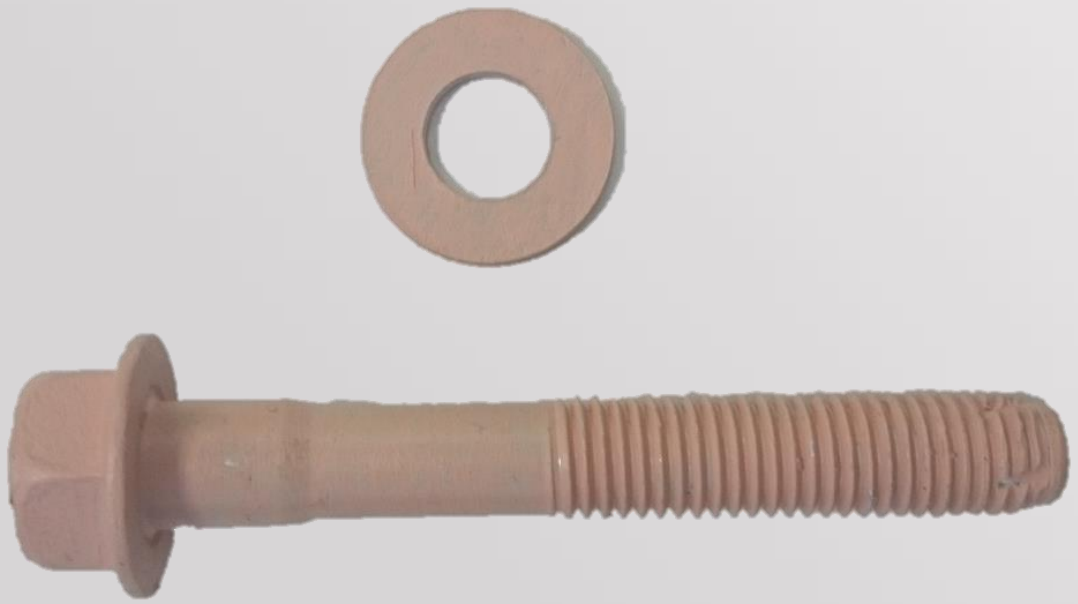
Objects with glossy finishes are difficult to scan because they can produce glare. But that does not mean it is not possible

Object material

The next piece is a metal screw. It may seems impossible to scan

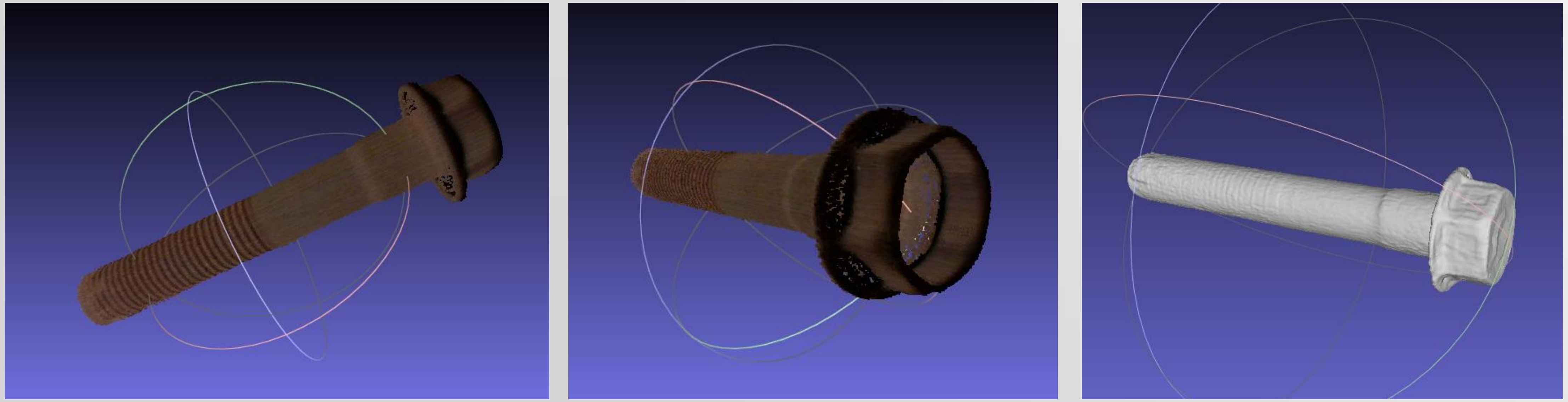
Object material

But there is the possibility of applying a watercolor or acrylic paint water-soluble covering the piece and remove all metallic sheen, making it matte



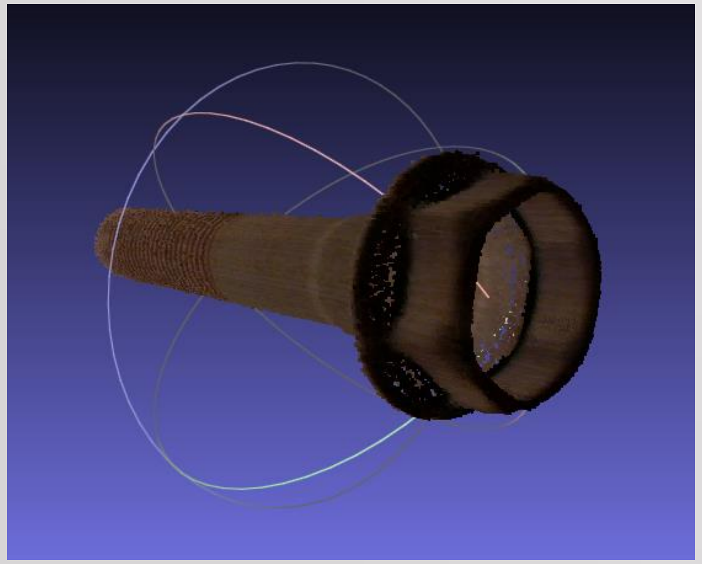
Object material

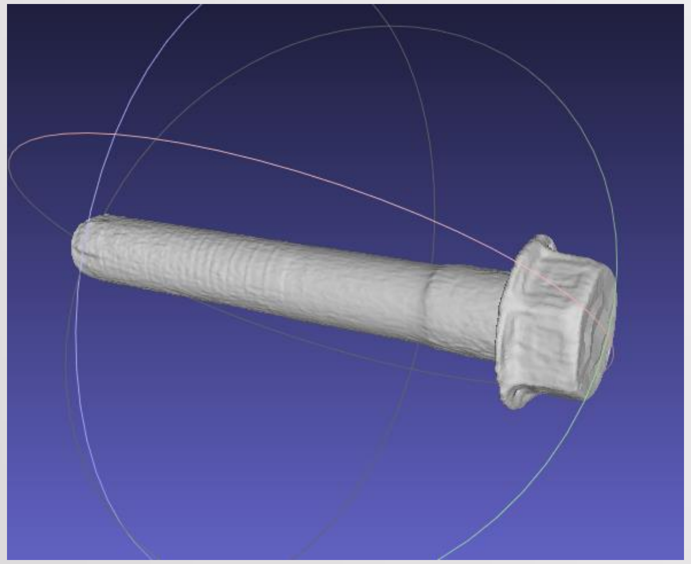
The result of scanning once this part is as follows:



Object material

A next step would be the possible re-design of the piece (applying a smoothing with a 3D software for example)



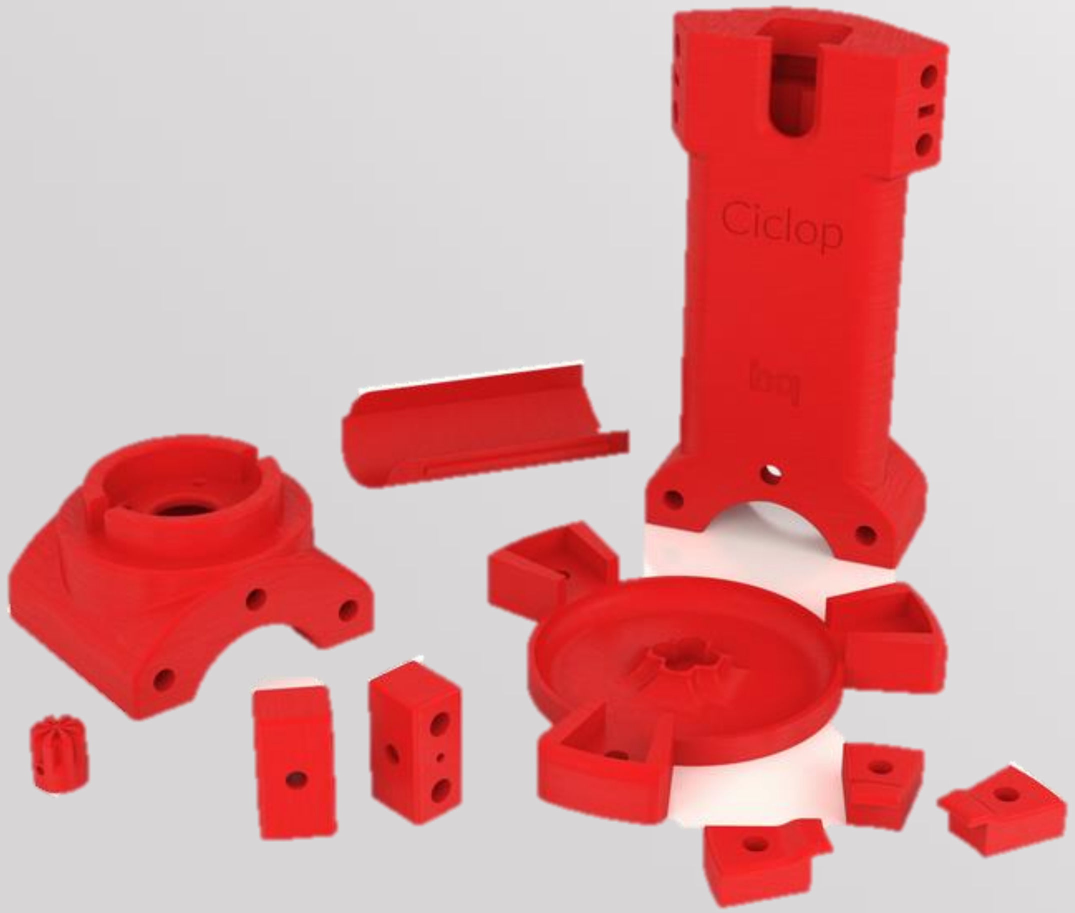


Object material

Another metallic example, which was painted and then scanned:

Object color

The laser beam is red, so that color objects can cause problems when it comes to recognition.



Object color

Light-colored objects can cause problems, especially in high brightness environments. In these cases it is recommended to decrease the brightness

Uncorrected brightness

Brightness diminished

Object color

In the same way that dark objects, the results can be inaccurate, especially in environments with little light

Uncorrected

Corrected

Object color

It is recommended to decrease the contrast and exposure increase a little, in addition to lowering the threshold

Uncorrected

Corrected

Object color

The ideal would be a non- aggressive or very intense color, matte and dull

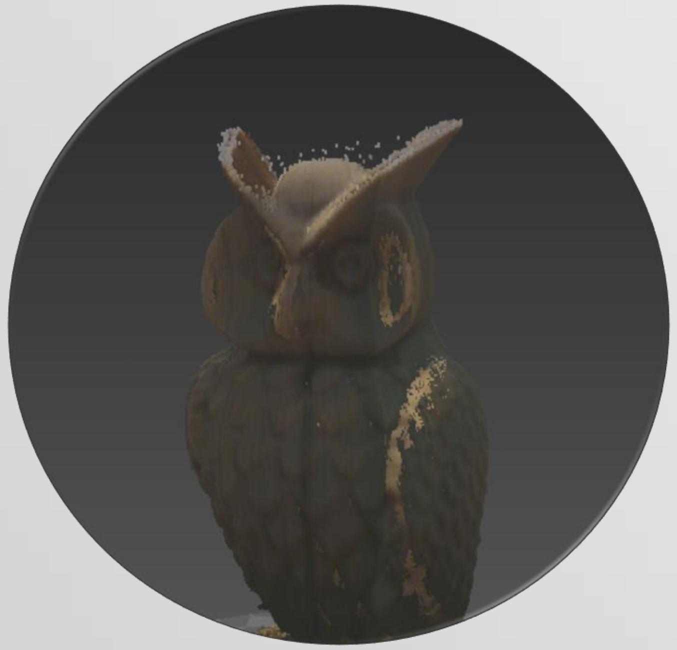


A beginning and an end

HORUS

Meshlab

Real piece



.PLY

.STL

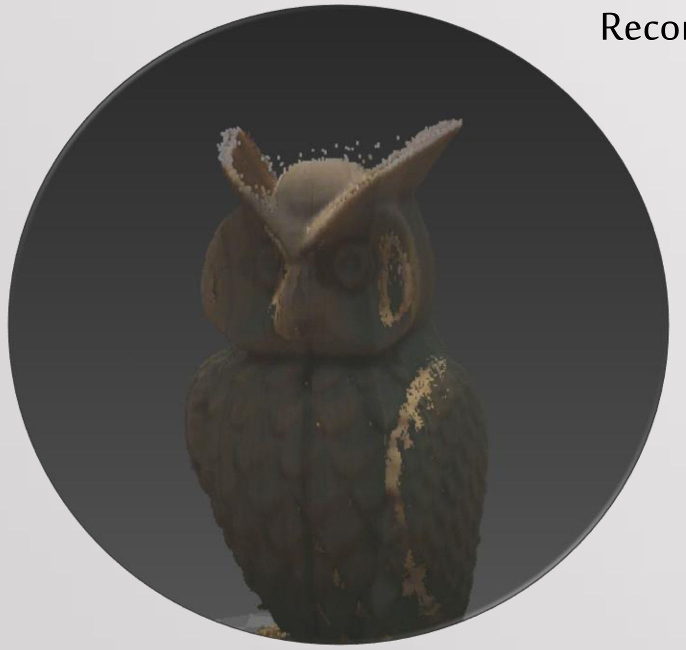
A beginning and an end

HORUS

Meshlab

Calibration

Scanning



Reconstruction

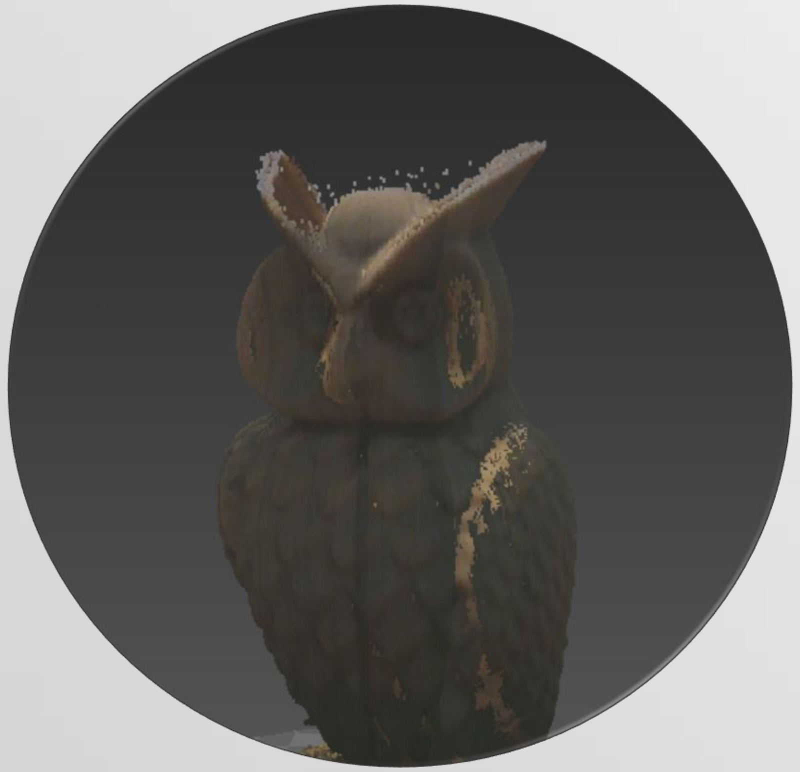
Real piece

.PLY

.STL

HORUS

First step: Calibrating and Obtaining a point cloud



bq

1. Wizard Mode

2. Control Workbench

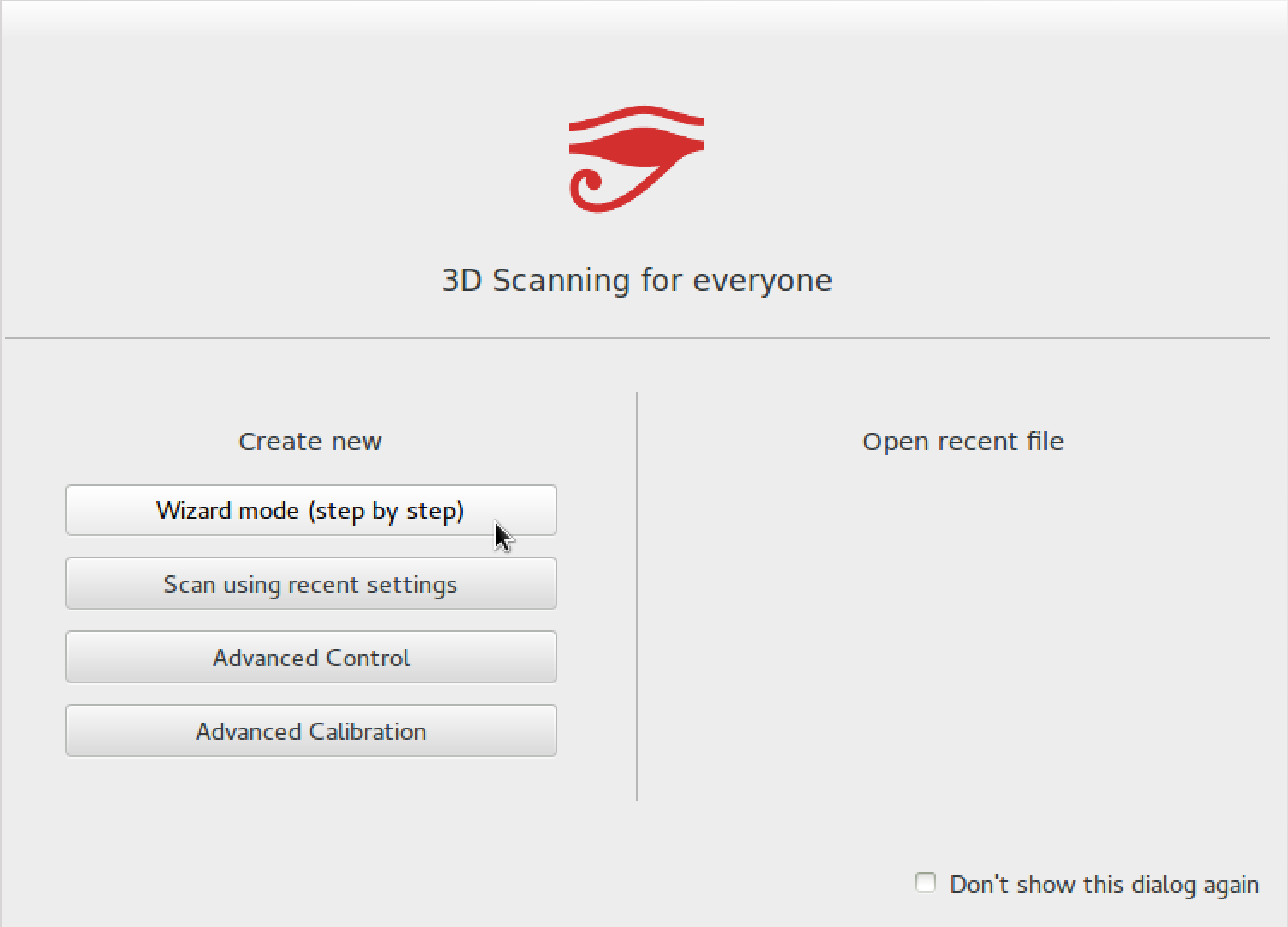
HORUS

3. Calibration Workbench

4. Scanning Workbench

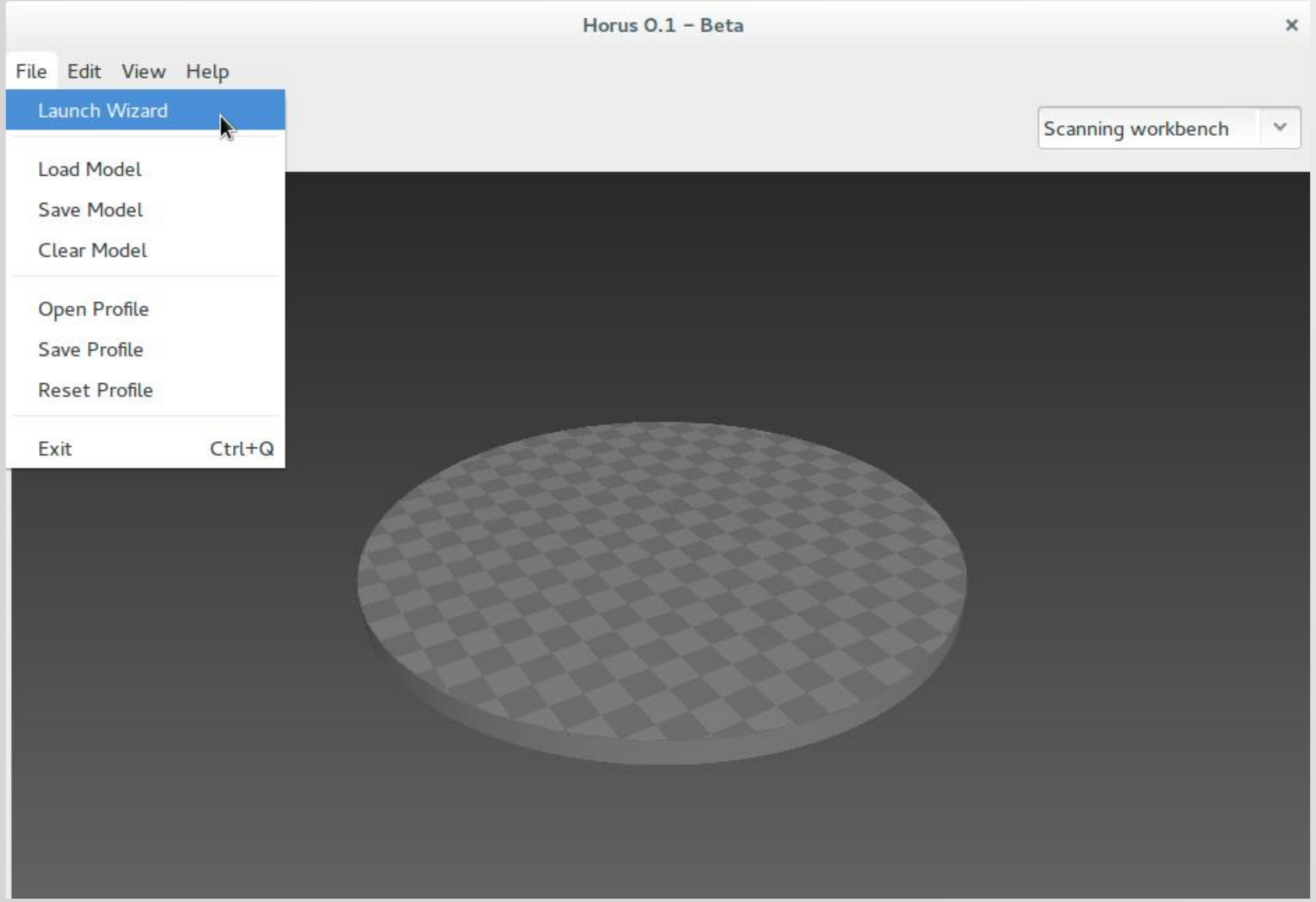
1. Wizard Mode

Horus has a way of using "step by step" for users with no experience in 3D scanning



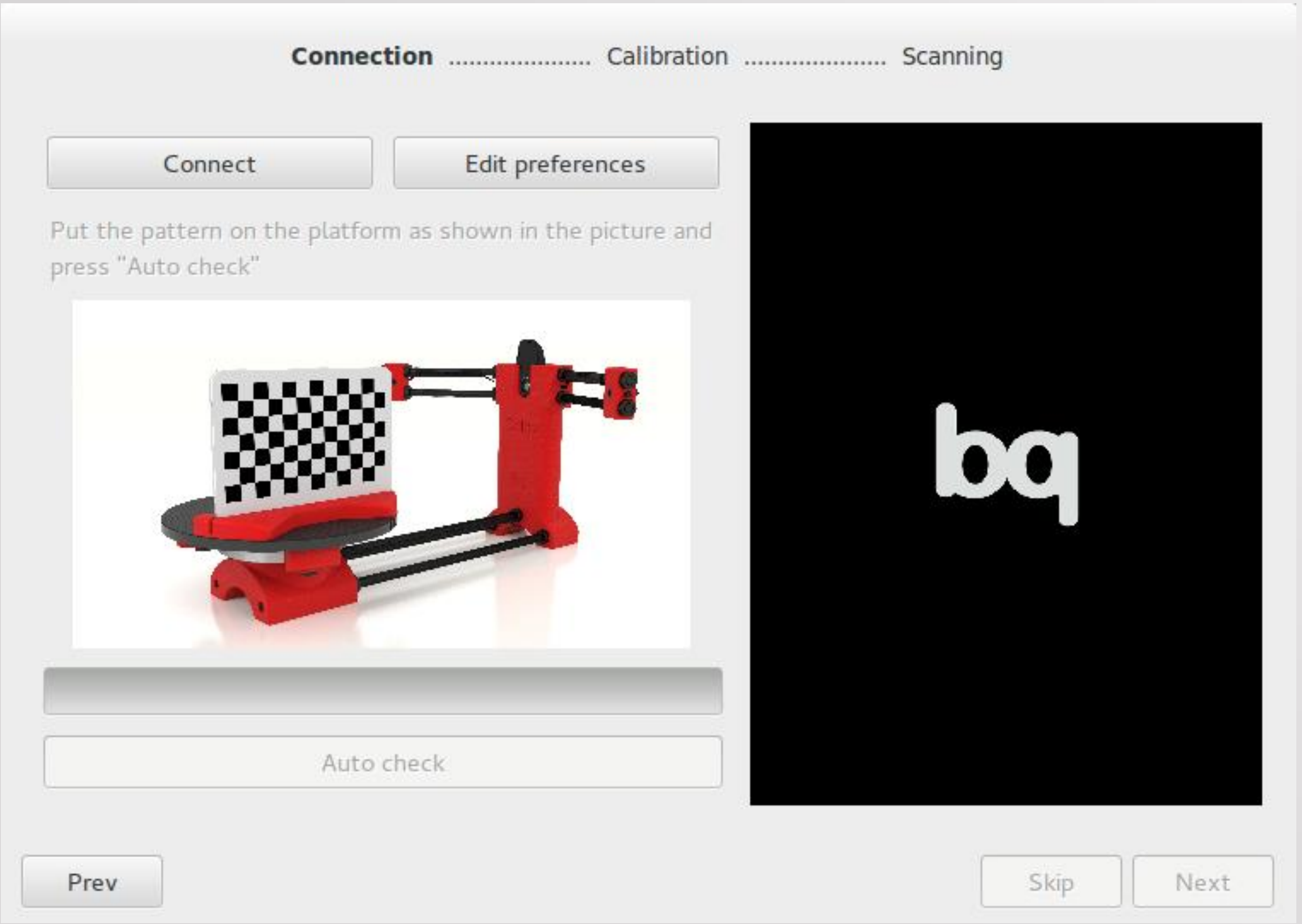
1. Wizard Mode

It opens every time the program is started, or from the File menu



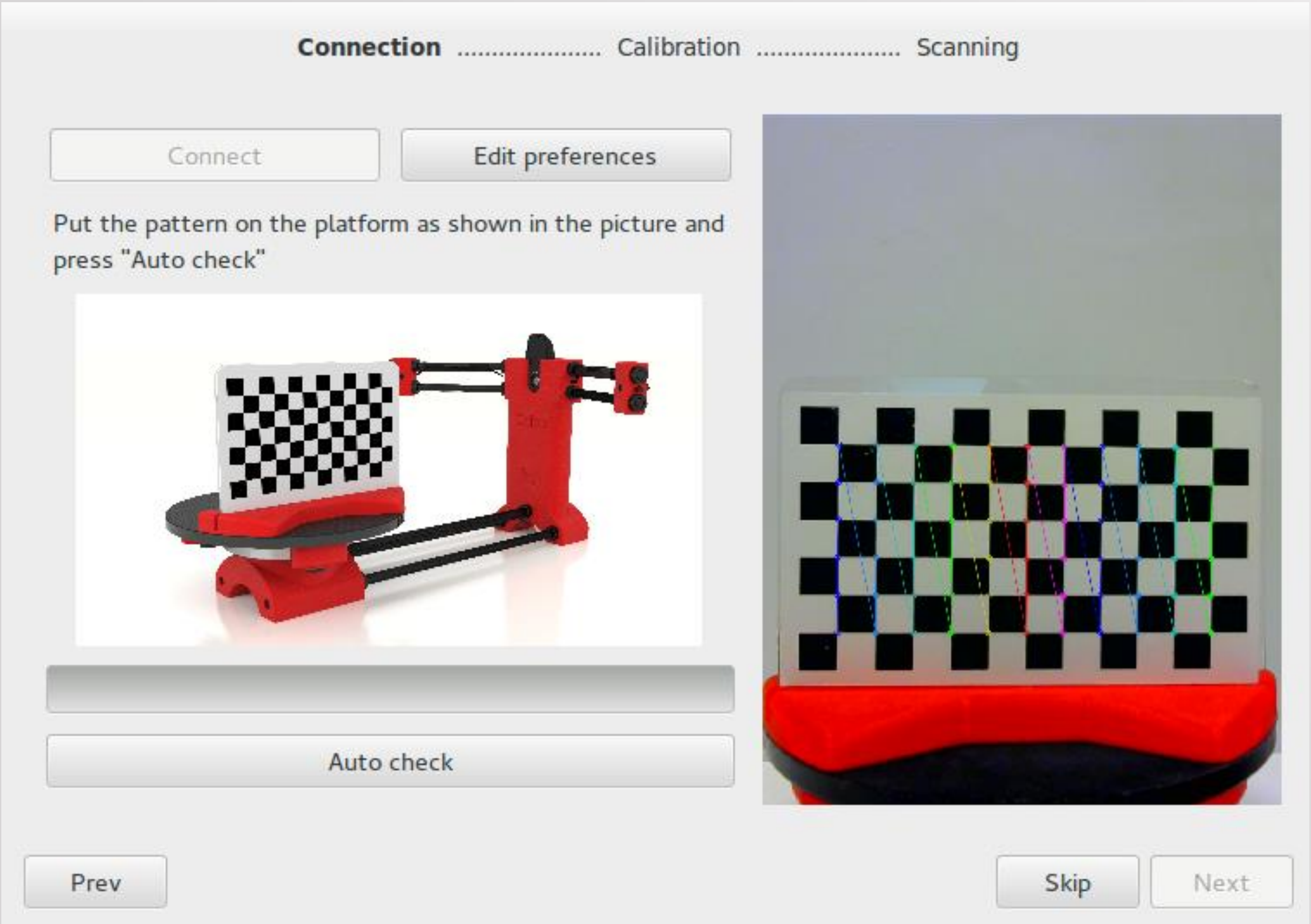
1. Wizard Mode

When you start the Wizard, this is the screen displayed



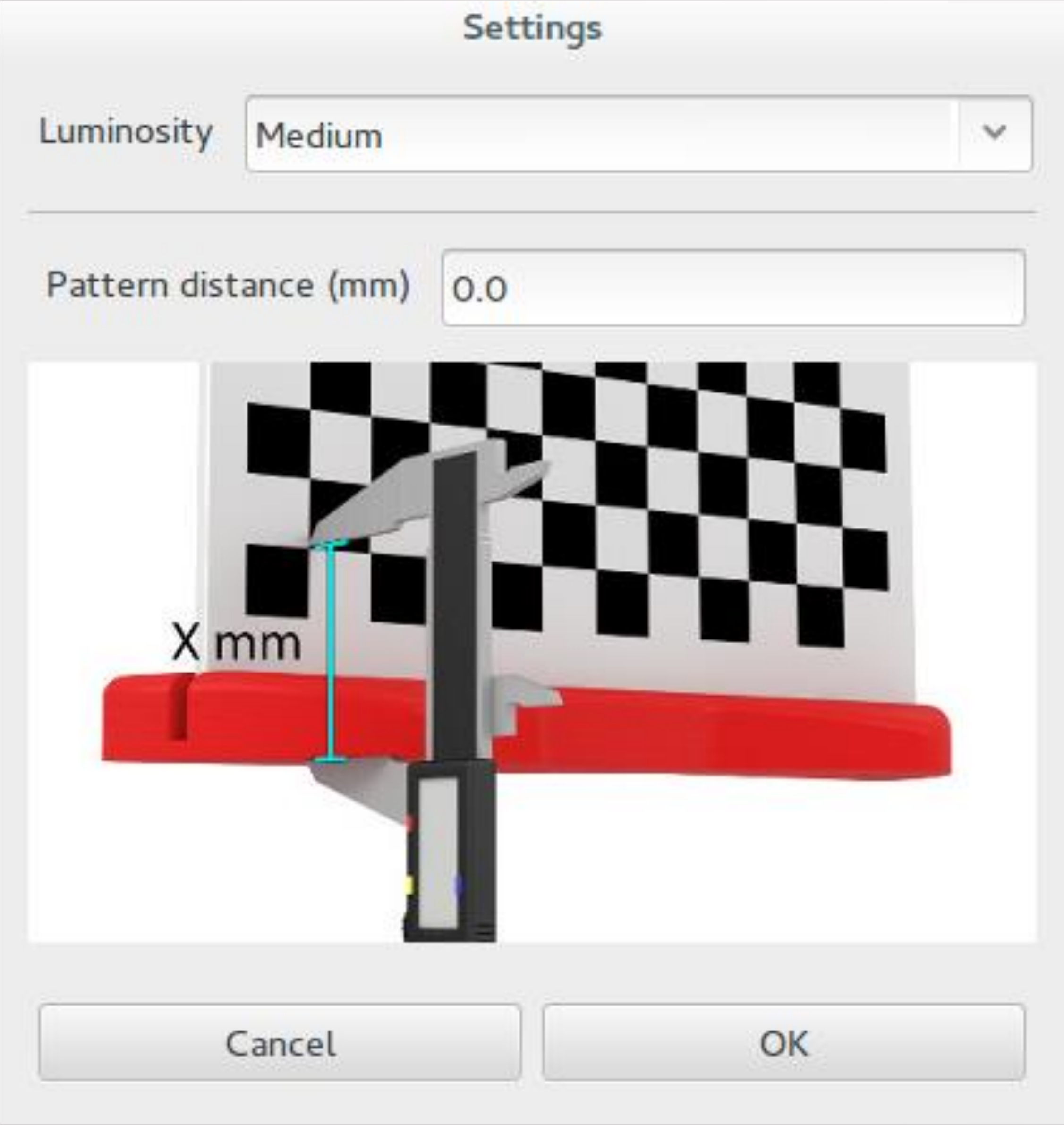
1. Wizard Mode

The first step is to press the Connect button. If everything is properly connected and configured, the video is displayed on the right side



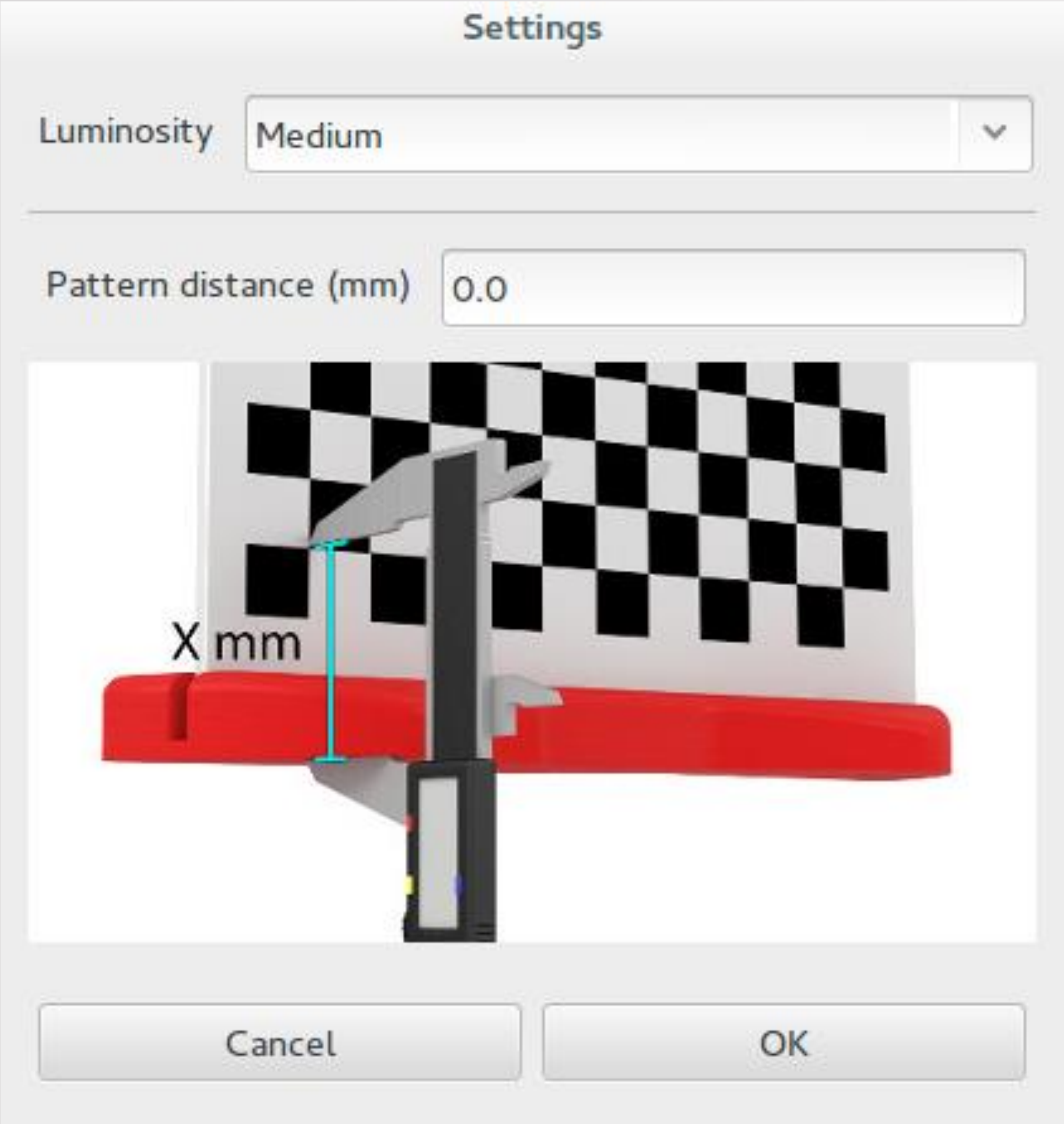
1. Wizard Mode

Next is to edit the preferences. The following configuration window appears



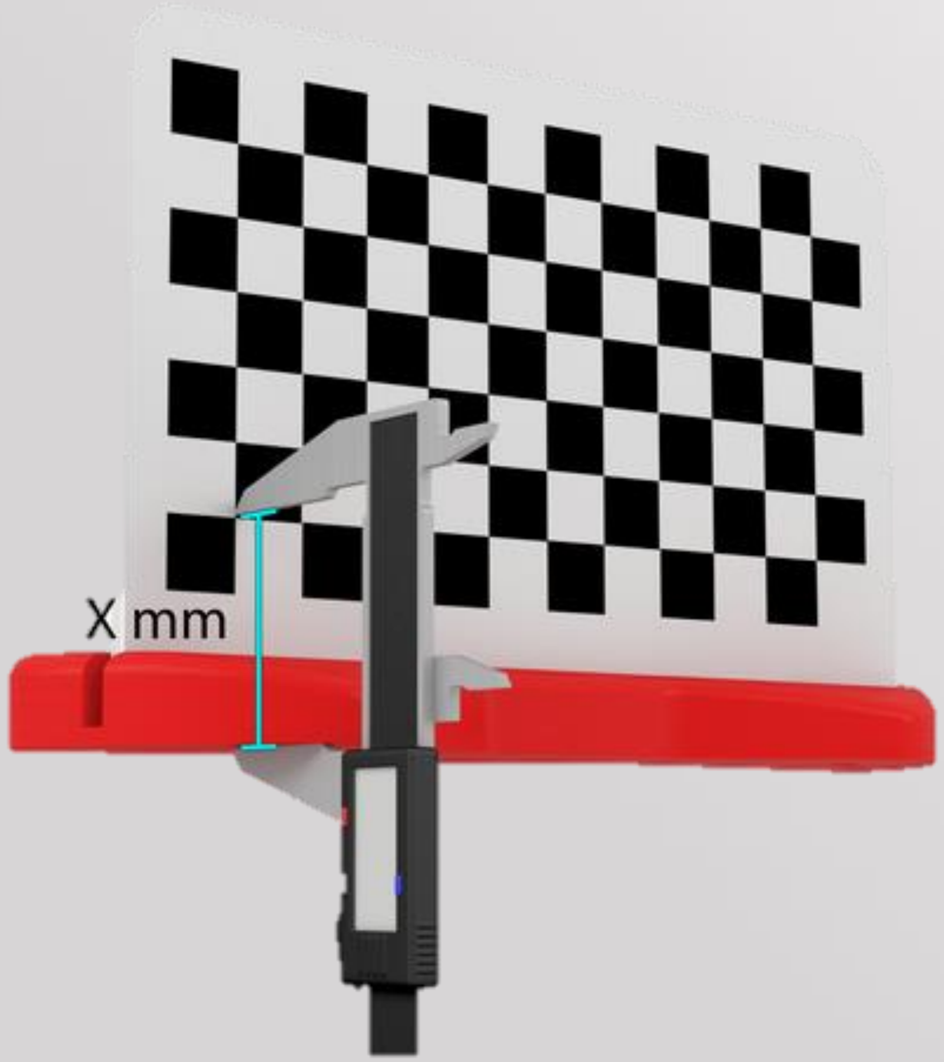
1. Wizard Mode

It may be modified brightness and distance of the pattern.



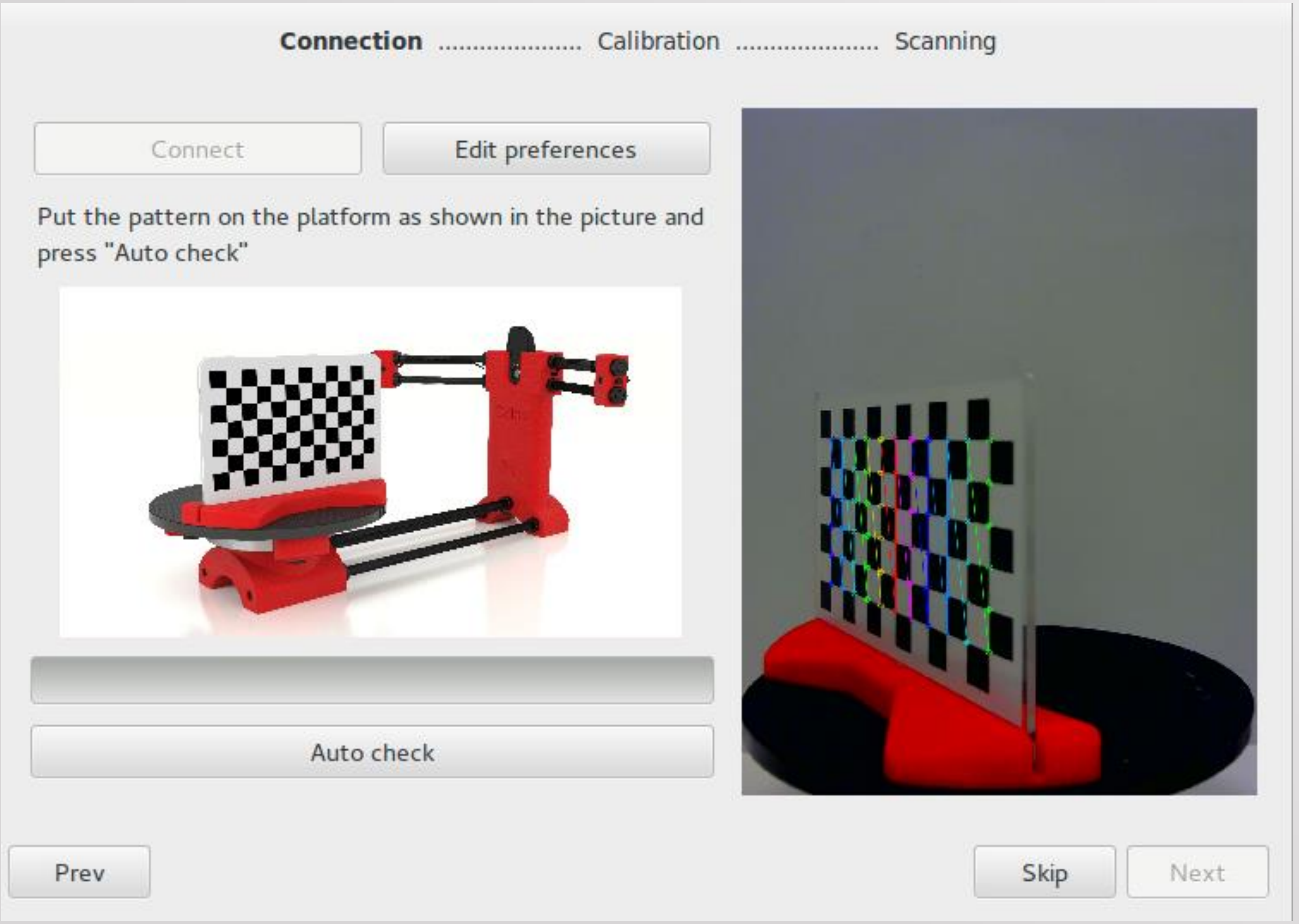
1. Wizard Mode

Pattern is the distance in mm, from the upper side of the square in the lower left part of the pattern to the rotating platform of the scanner



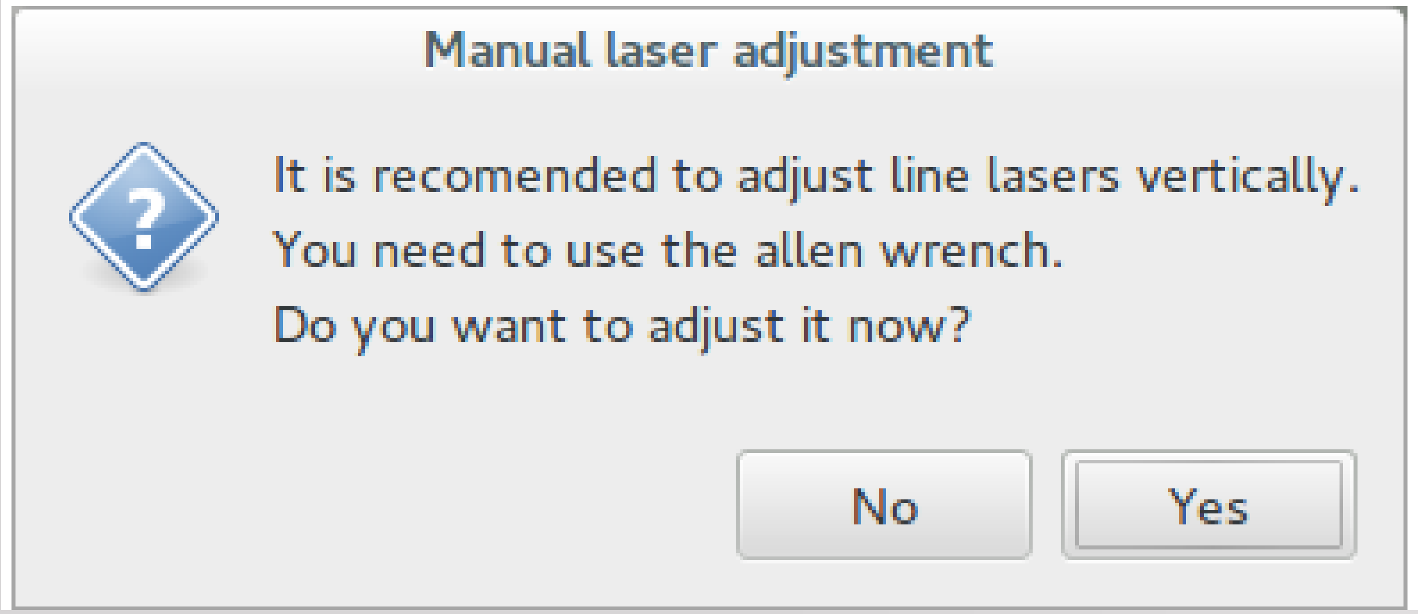
1. Wizard Mode

It is very important to place the pattern as indicated in Figure. Then select Auto-Check



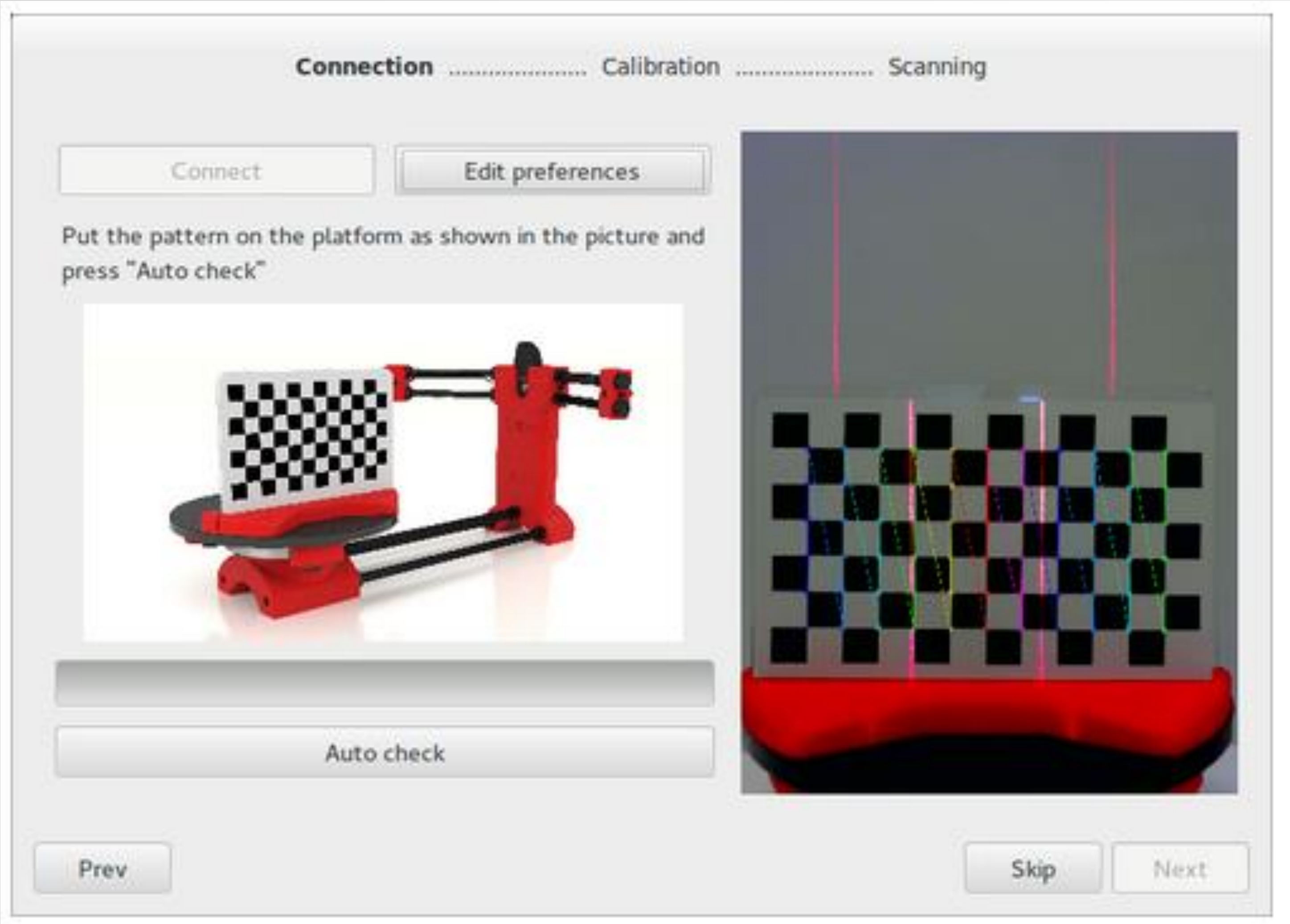
1. Wizard Mode

If this is the first time the scanner is configured, the following window will appear. This dialogue lasers recommend setting manually to get a vertical position.



1. Wizard Mode

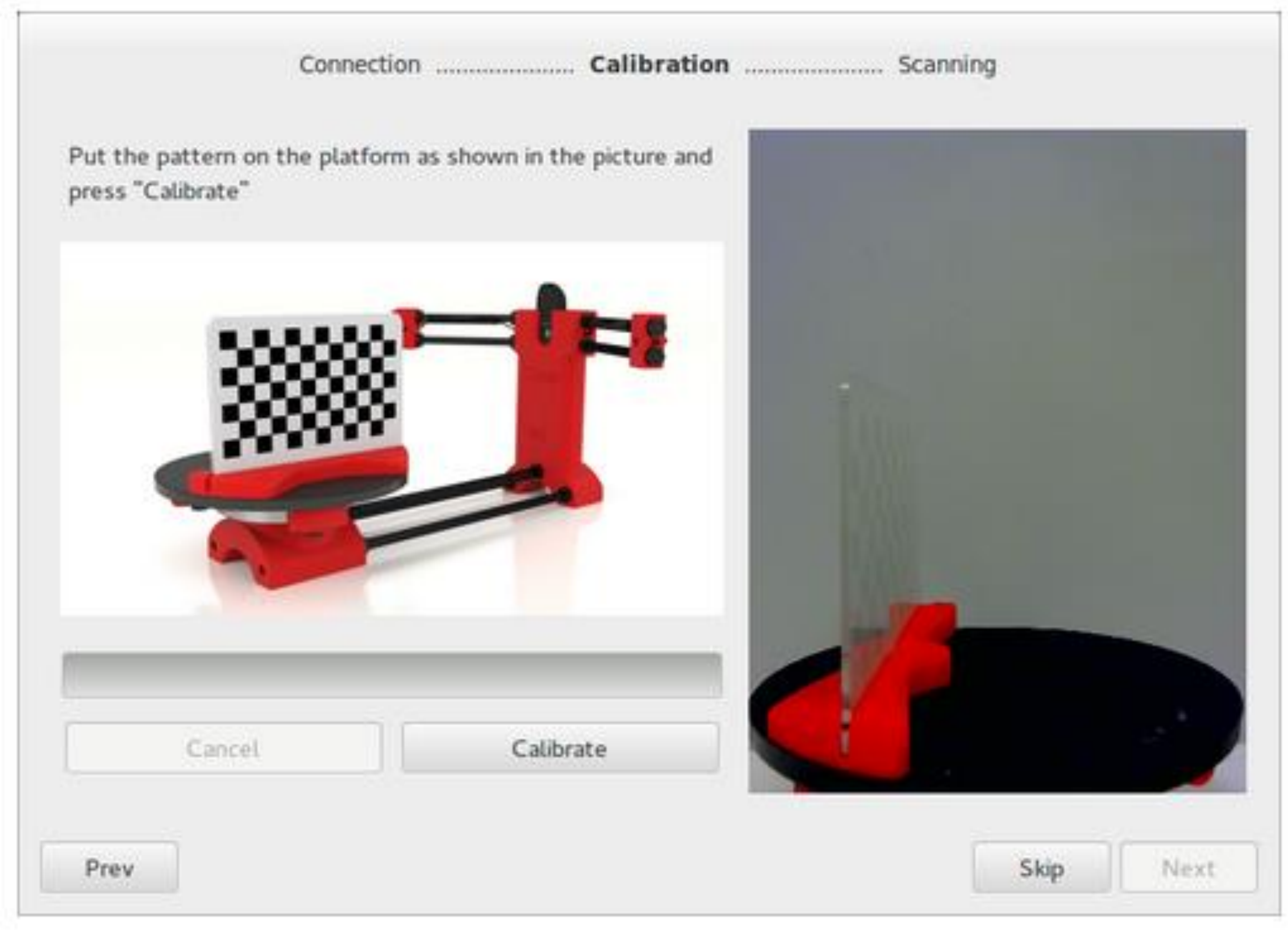
If the button YES is pressed both lasers will light. Using the calibration pattern, lasers will be placed vertically. To make this adjustment we will use the screws



1. Wizard Mode

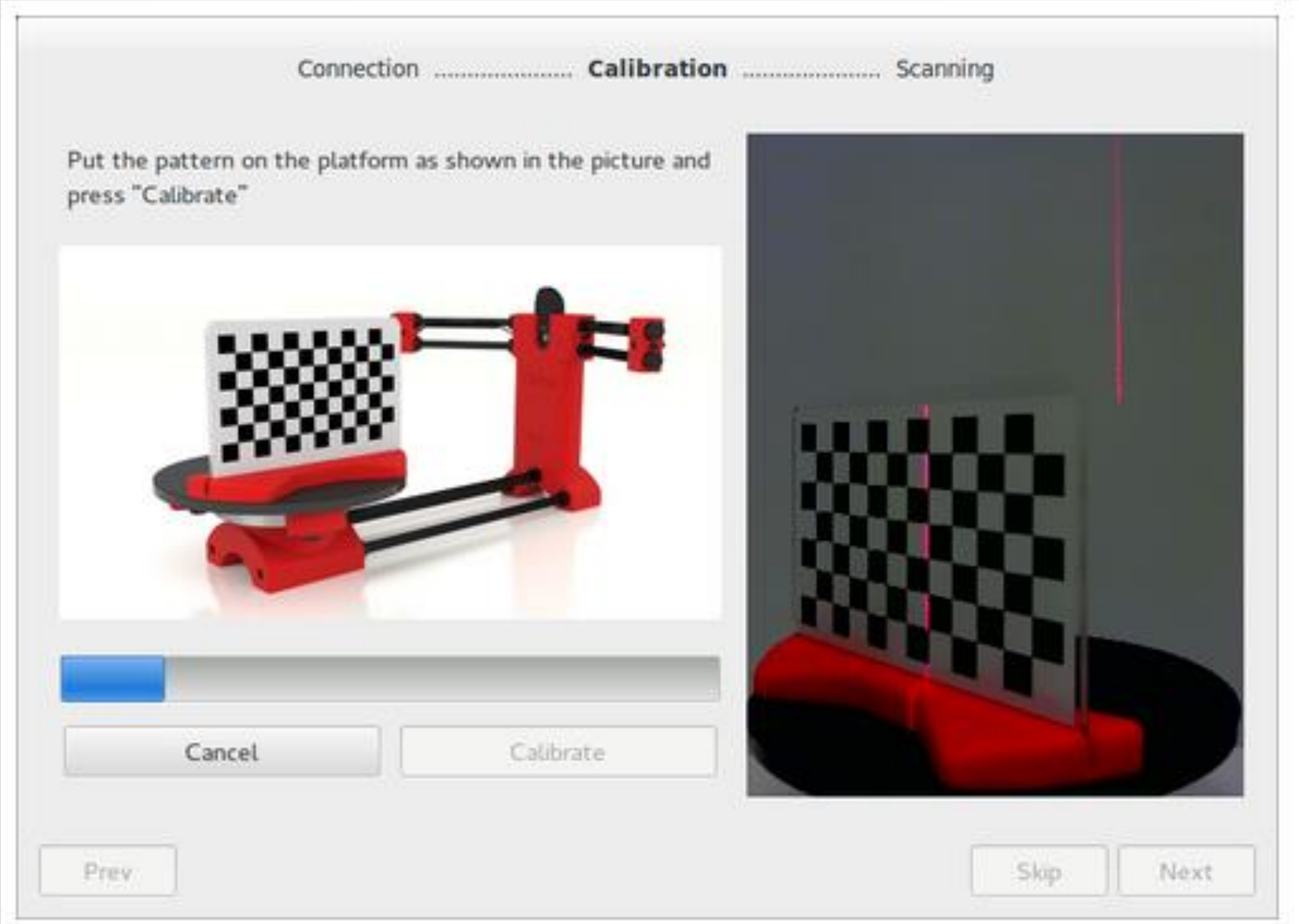
bq

After clicking Next, we turn to the calibration. We place the pattern as the figure and click Calibrate



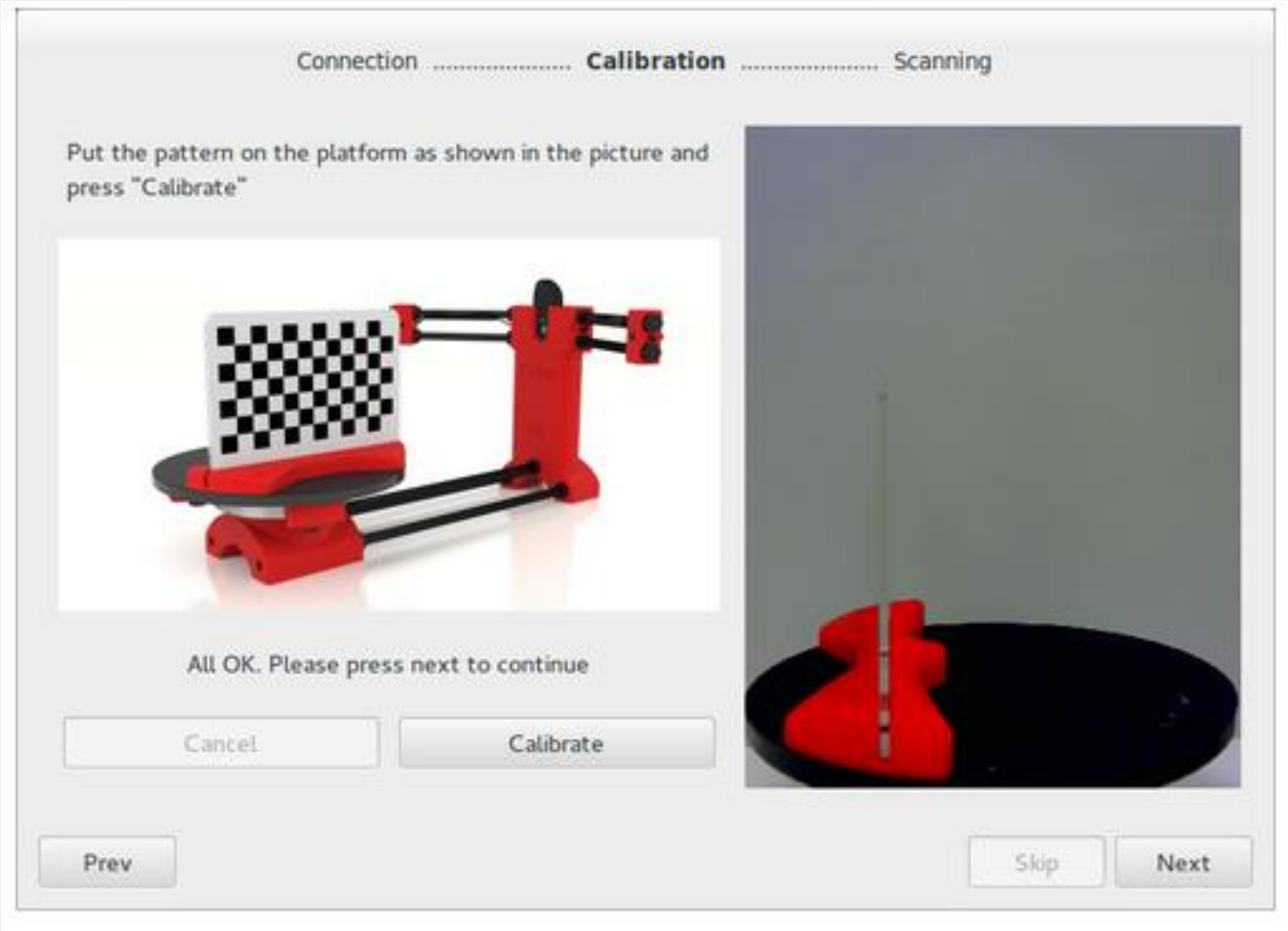
1. Wizard Mode

After pressing Calibrate, start the process



1. Wizard Mode

Once finished, if everything is correct, the message "All OK" is displayed



1. Wizard Mode

The last step of the Wizard will set the scan preferences. This screen shows the available options

1. Wizard Mode

Resolution: High resolution, Medium resolution, Low resolution. The higher it is, the higher the scan time

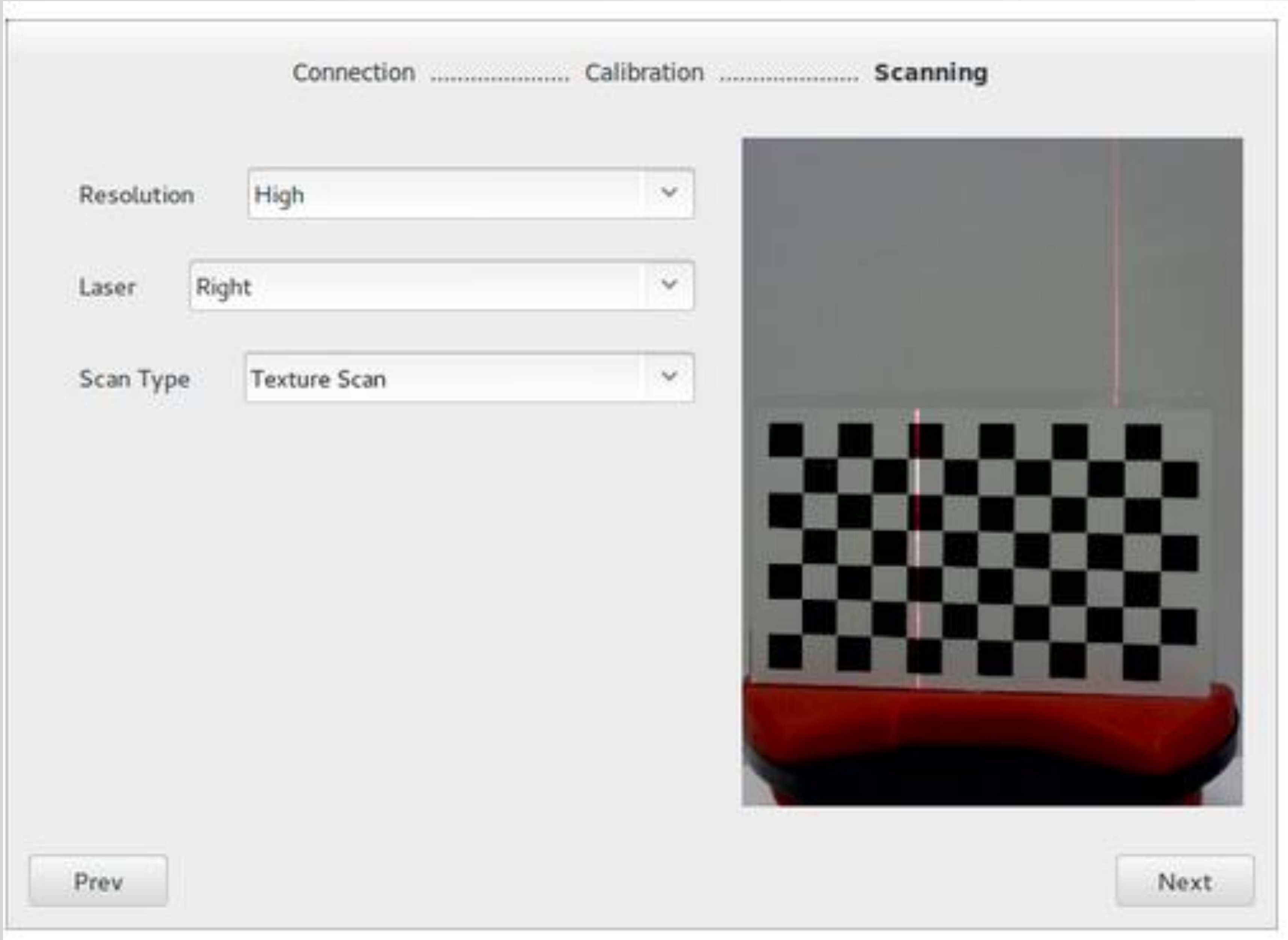
1. Wizard Mode

Laser: It can be used the left laser, right laser, or both. If we use both, the amount of scanned points will be higher, so our piece will be more detailed

1. Wizard Mode

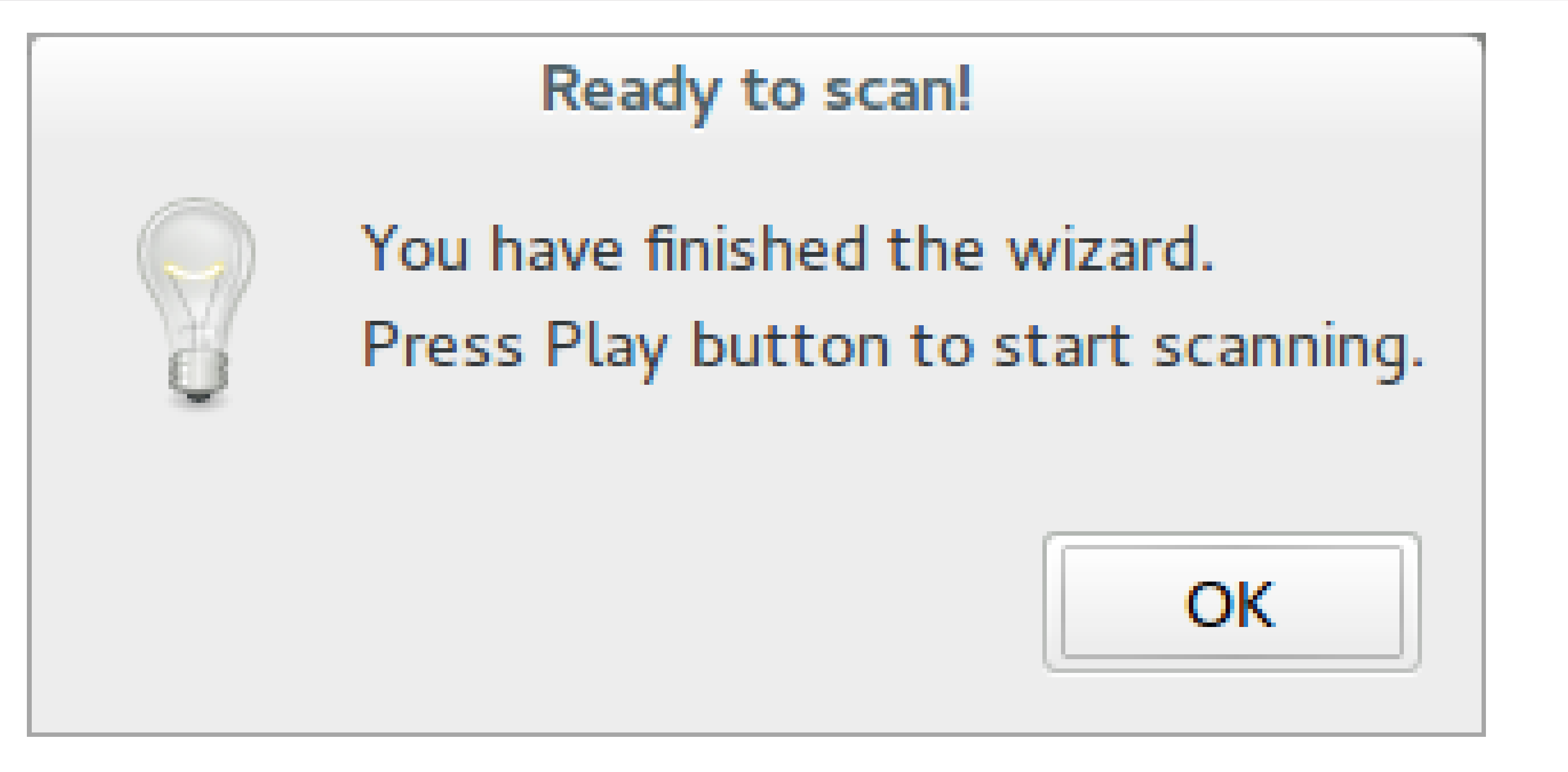
Scanning Type: It can be used Simple scanning or With Texture. The simple scanning doesn't catch the object color. The scanning with texture uses 2 Images to catch the laser, generating the mesh of points with the real colors of the object

1. Wizard Mode



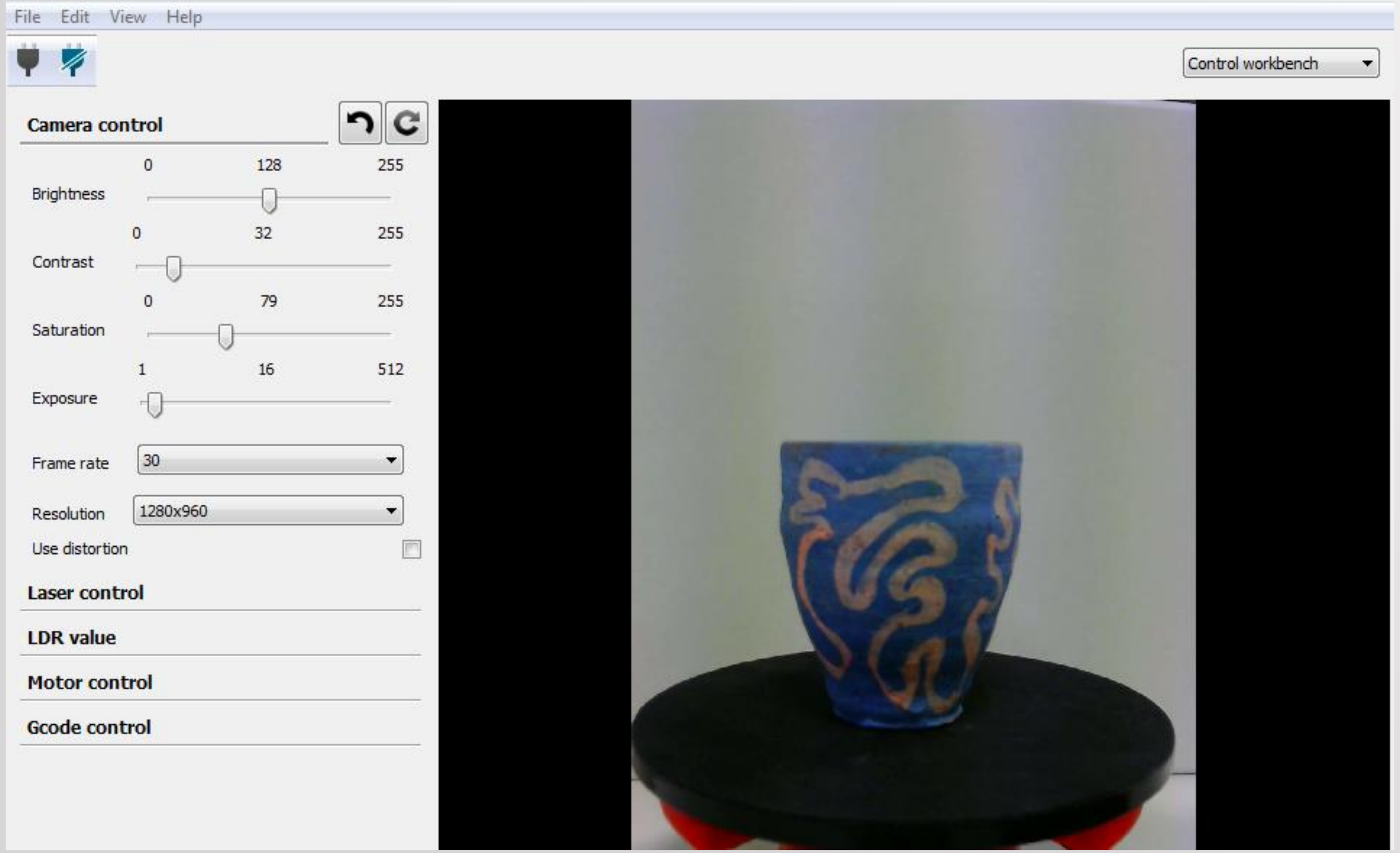
1. Wizard Mode

Once the Preference Scanning Settings are finished, we press Next, and the scanner will be ready to start working



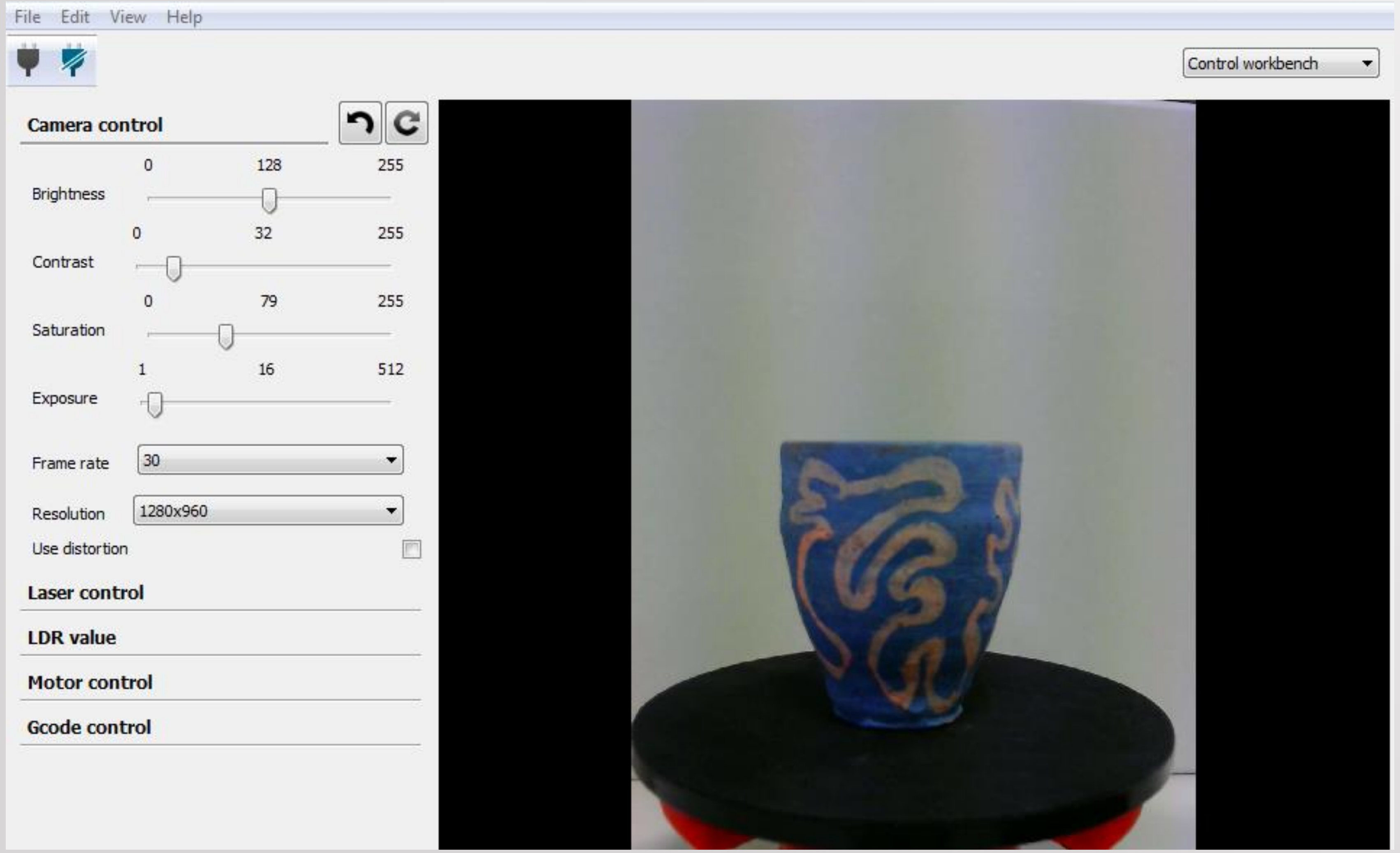
2. Control Workbench

Control of the parameters one by one



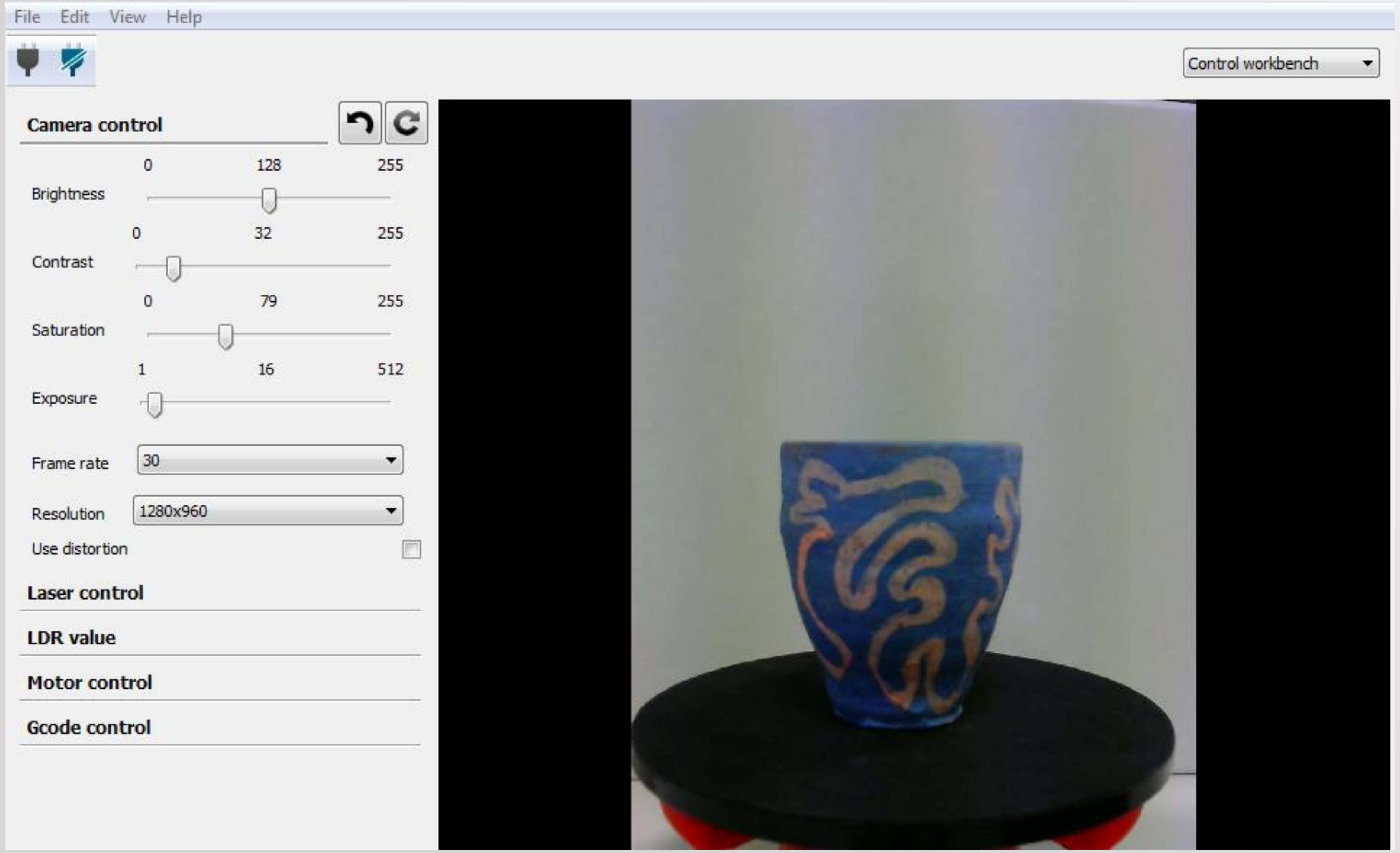
2. Control Workbench

The changes made into the workbench do not affect to the others



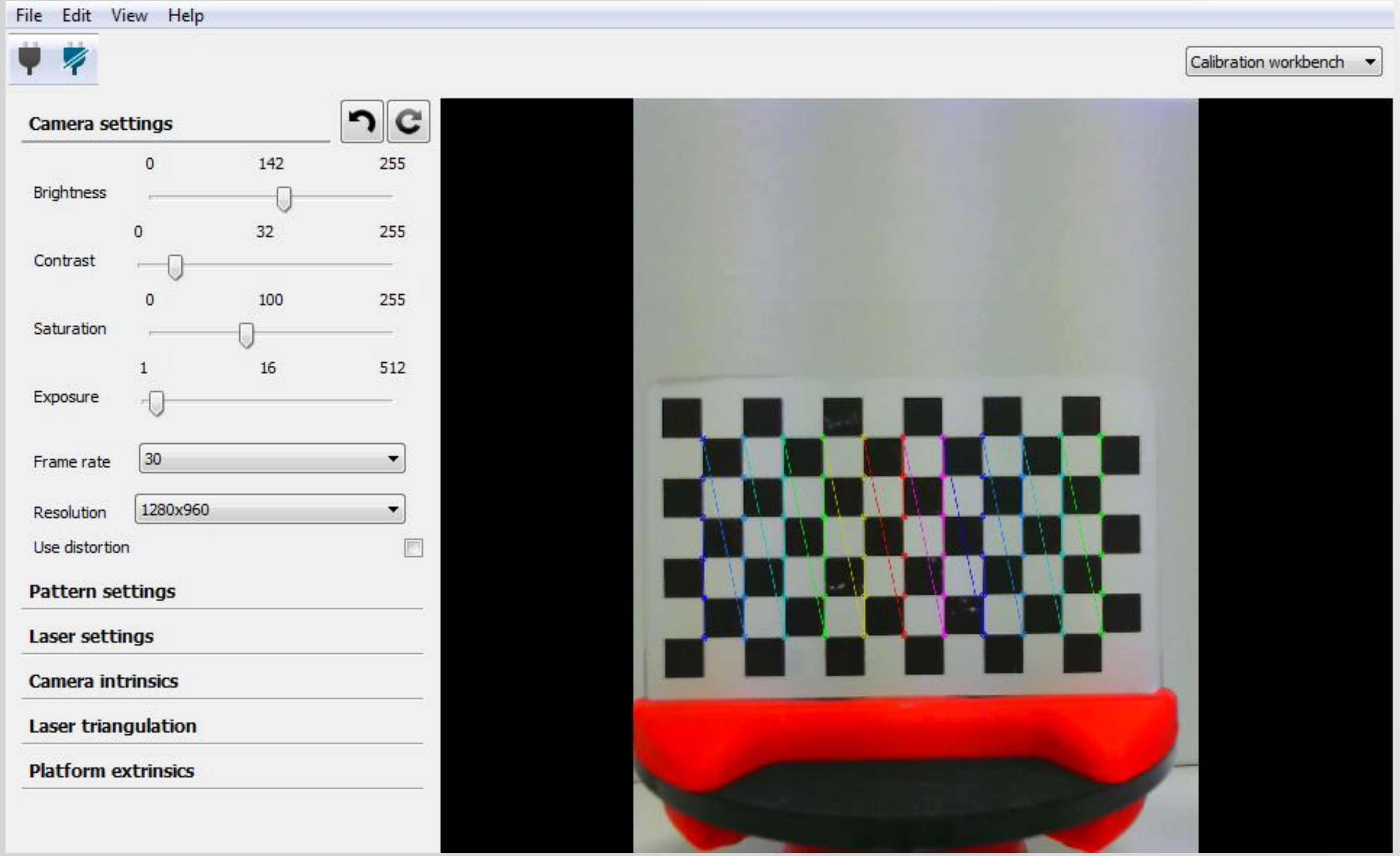
2. Control Workbench

Its goal is to experiment and learn about the different parameters



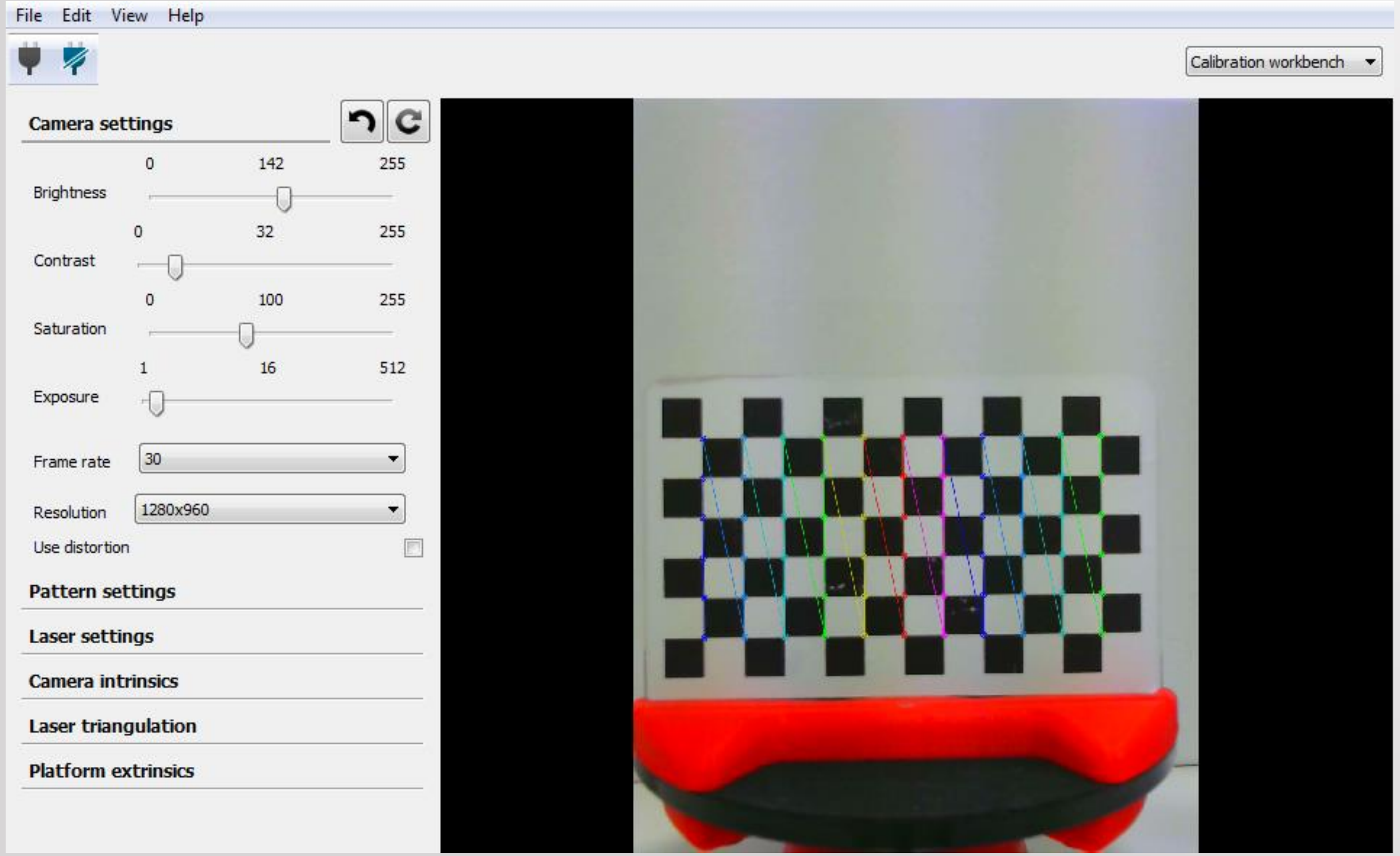
3. Calibration Workbench

Calibration of the different components of the laser



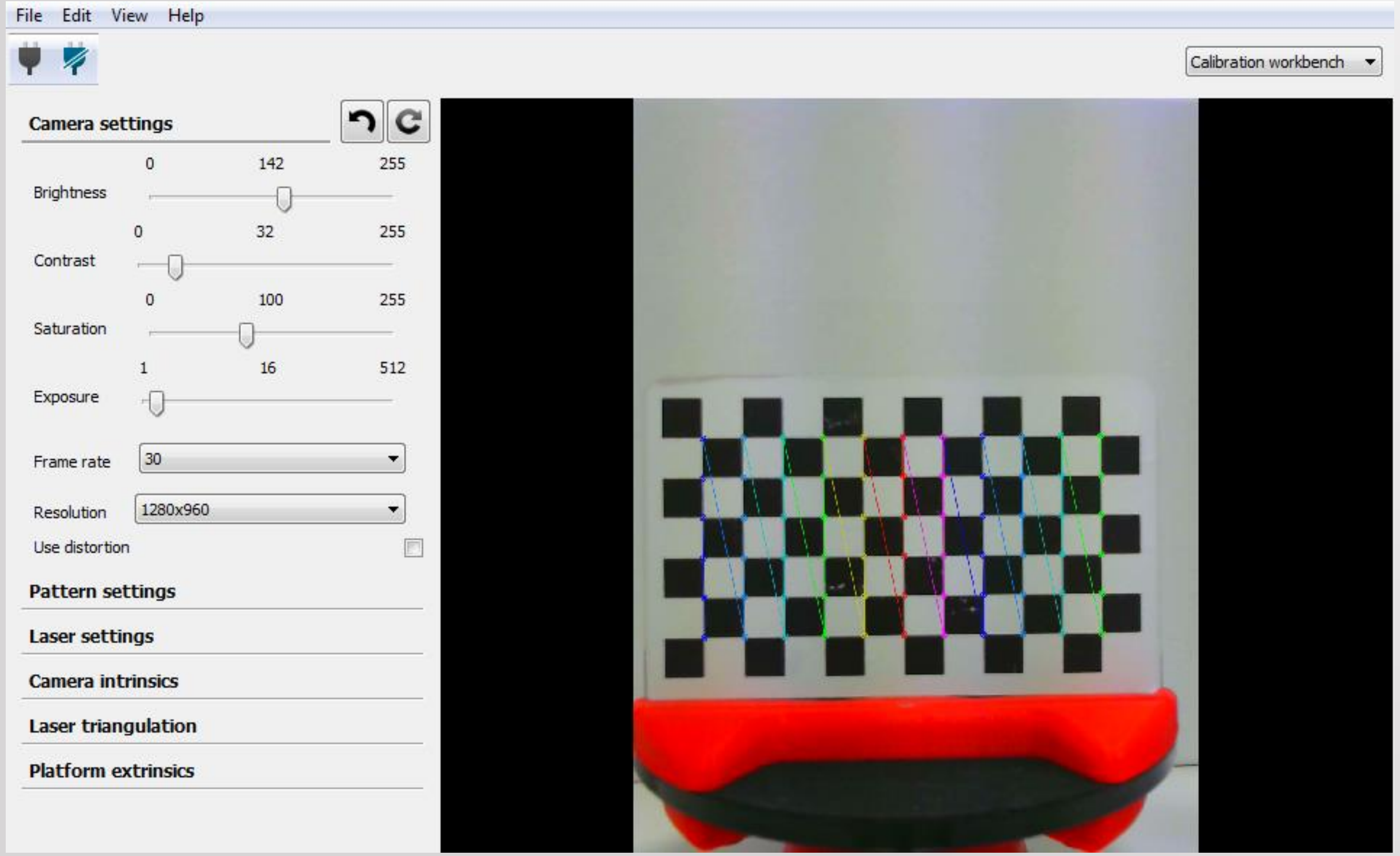
3. Calibration Workbench

The changes made into the workbench affect to the others



3. Calibration Workbench

This process will be essential to obtain a good result



3. Calibration Workbench

It will consist of:

- Camara settings
- Patern settings
- Laser settings

+

- Intrinsics calibration
- Laser triangulation
- Extrinsics calibration

3. Calibration Workbench

Camera Settings:

The camera settings aims to ensure that the pattern is detected correctly, in different positions

Camera Settings

and lighting conditions of the scene.

3. Calibration Workbench

Camera Settings

3. Calibration Workbench

Camera Settings

Brightness: Brightness of the image

3. Calibration Workbench

Camera Settings

Contrast: Relative intensity difference

3. Calibration Workbench

Camera Settings

Saturation: Intensity of color image

3. Calibration Workbench

Camera Settings

Exposure Time lens aperture (milliseconds)

3. Calibration Workbench

Camera Settings

Framerate: Images captured per second

Resolution: Image size. 4:3

Distortion: Distortion correction lens according to the calibration

3. Calibration Workbench

Patern Settings:

Calibration is done by a pattern

3. Calibration Workbench

Patern Settings:

By default comes configured according to the one it comes with Ciclop

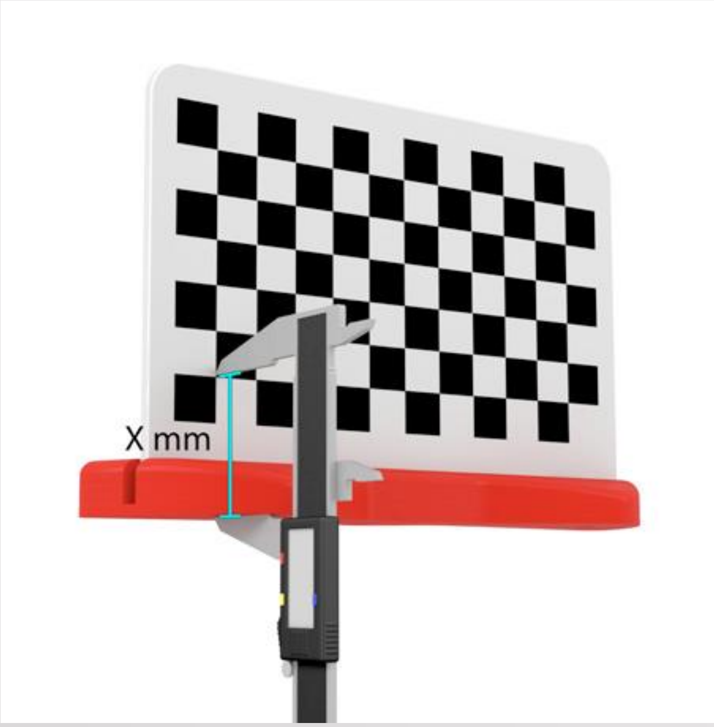
Square width	13
Pattern rows	6
Pattern columns	11
Pattern distance	37.5

3. Calibration Workbench

Patern Settings:

The distance set will be the one shown in Figure

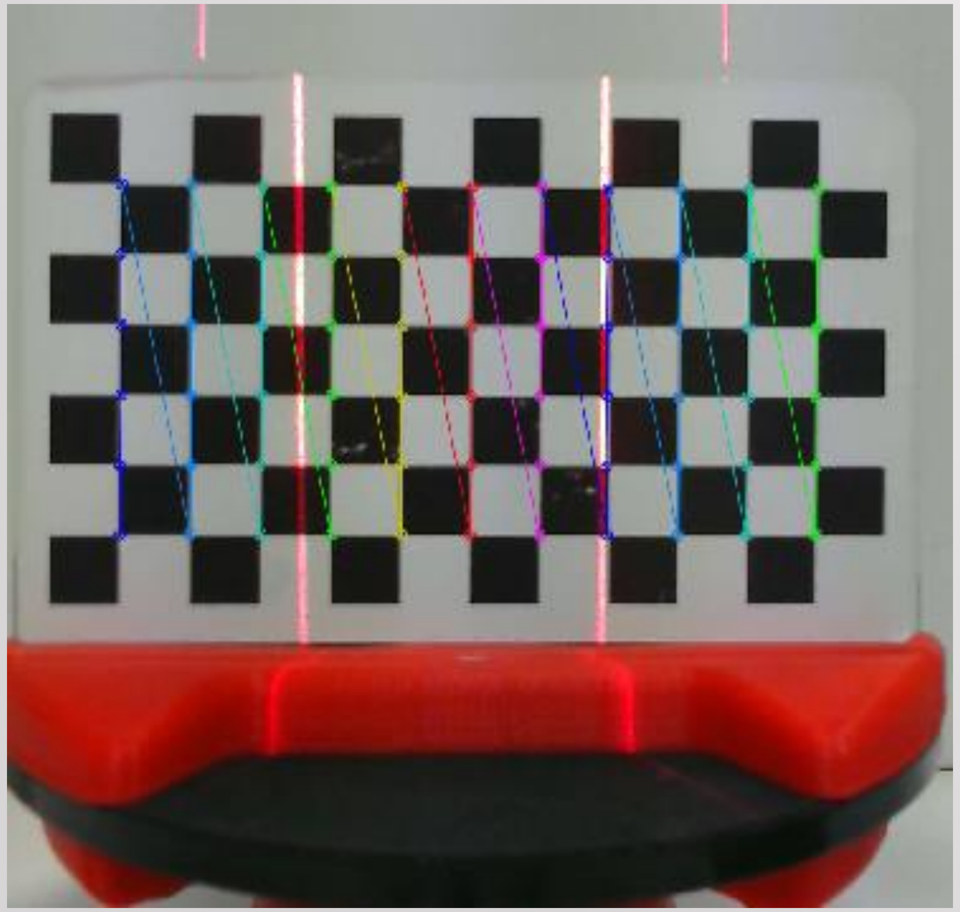
Square width	13
Pattern rows	6
Pattern columns	11
Pattern distance	37.5



3. Calibration Workbench

Laser Settings:

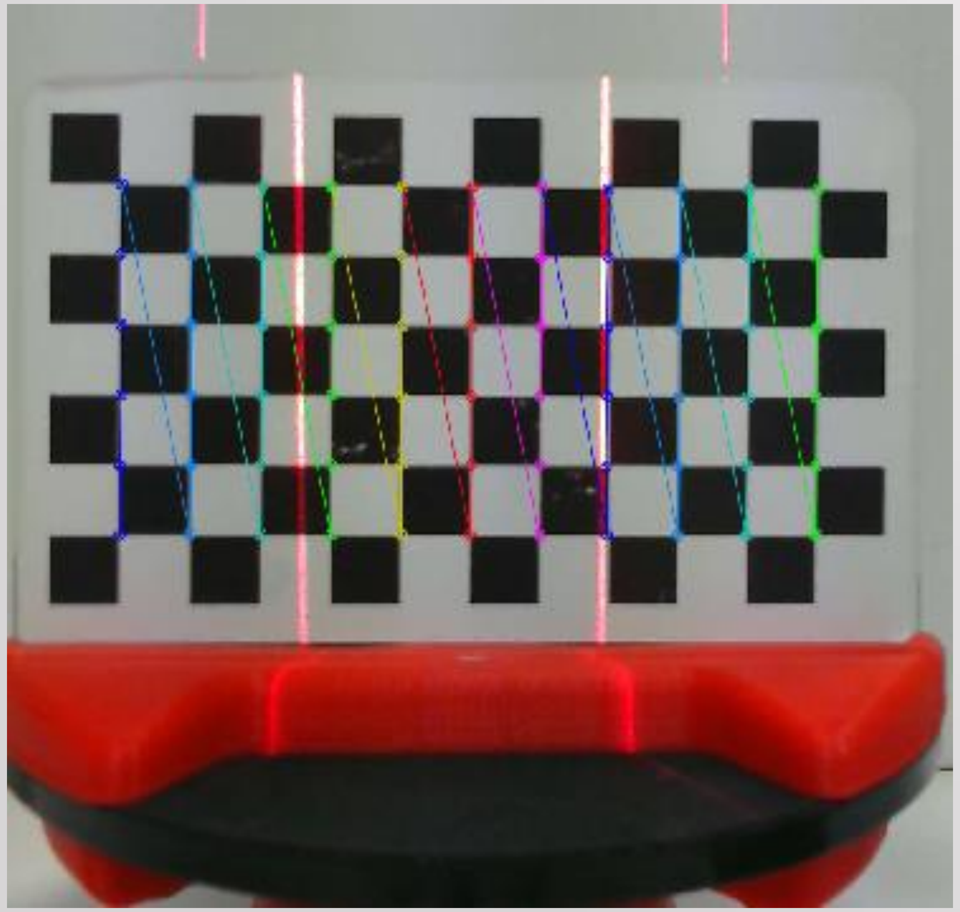
Option Enable / Disable right, left Laser, or both



3. Calibration Workbench

Laser Settings:

They should be adjusted to be completely vertical relative to the platform



3. Calibration Workbench

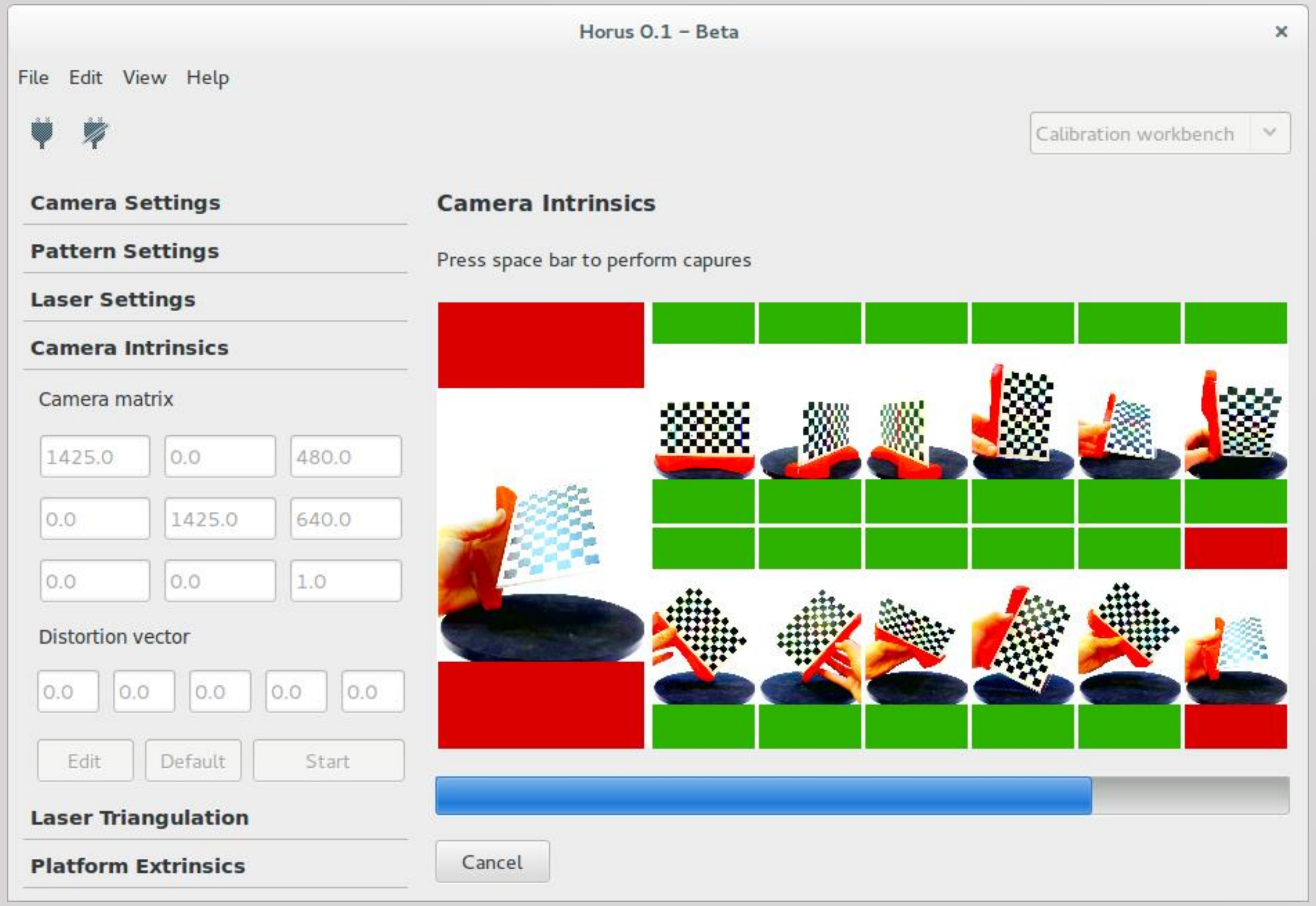
Intrinsics Calibration:

The aim is to calculate:

- Focal lengths
- Optical center
- Lens distorsion

3. Calibration Workbench

Intrinsics Calibration:



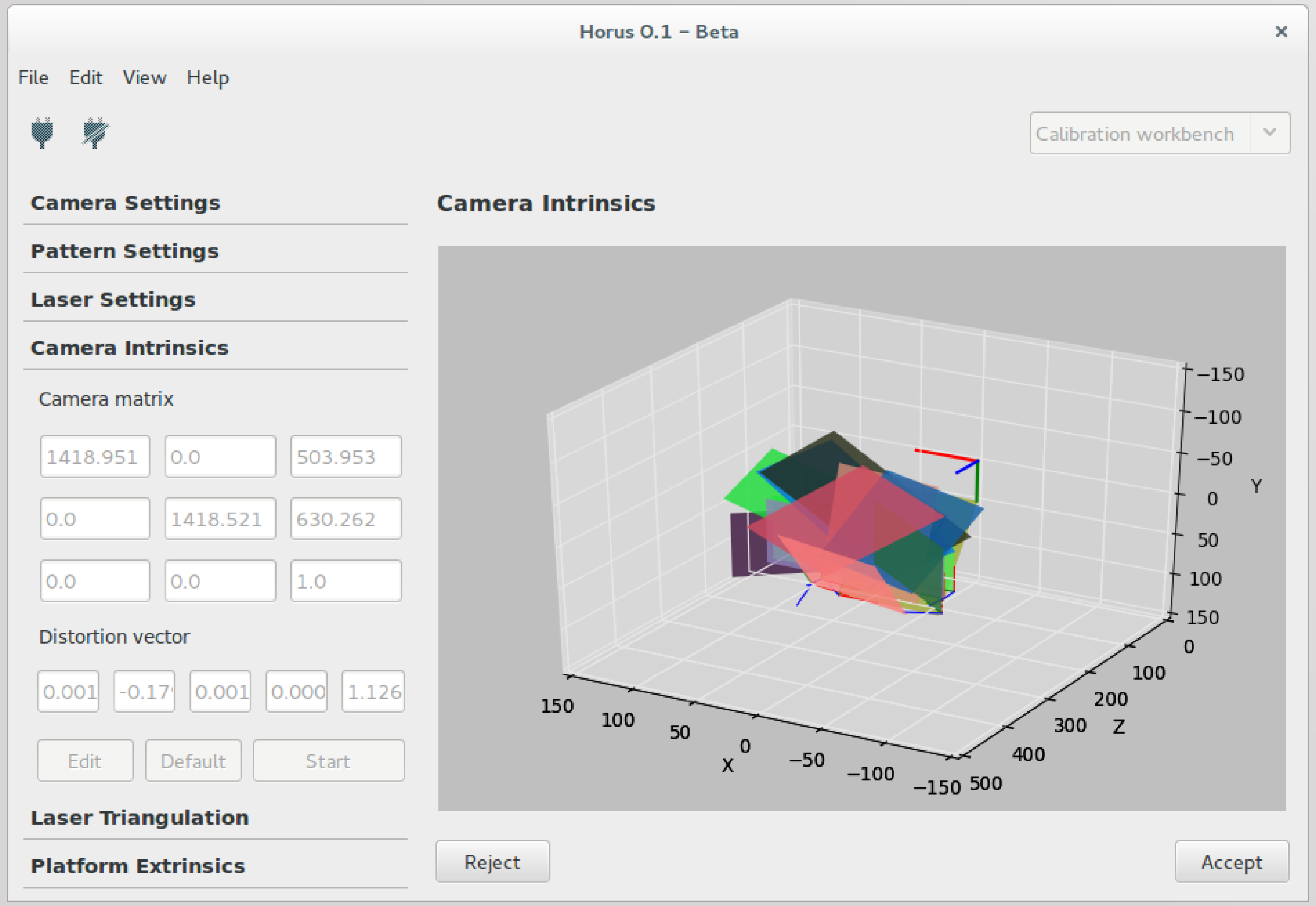
We capture 12 pattern images in different positions.

If the frame is green, the image is valid.

It is advised that the positions are as different as possible.

3. Calibration Workbench

Intrinsics Calibration:



The result is displayed numerically and graphically.

At this point, we can accept or reject the calibration.

3. Calibration Workbench

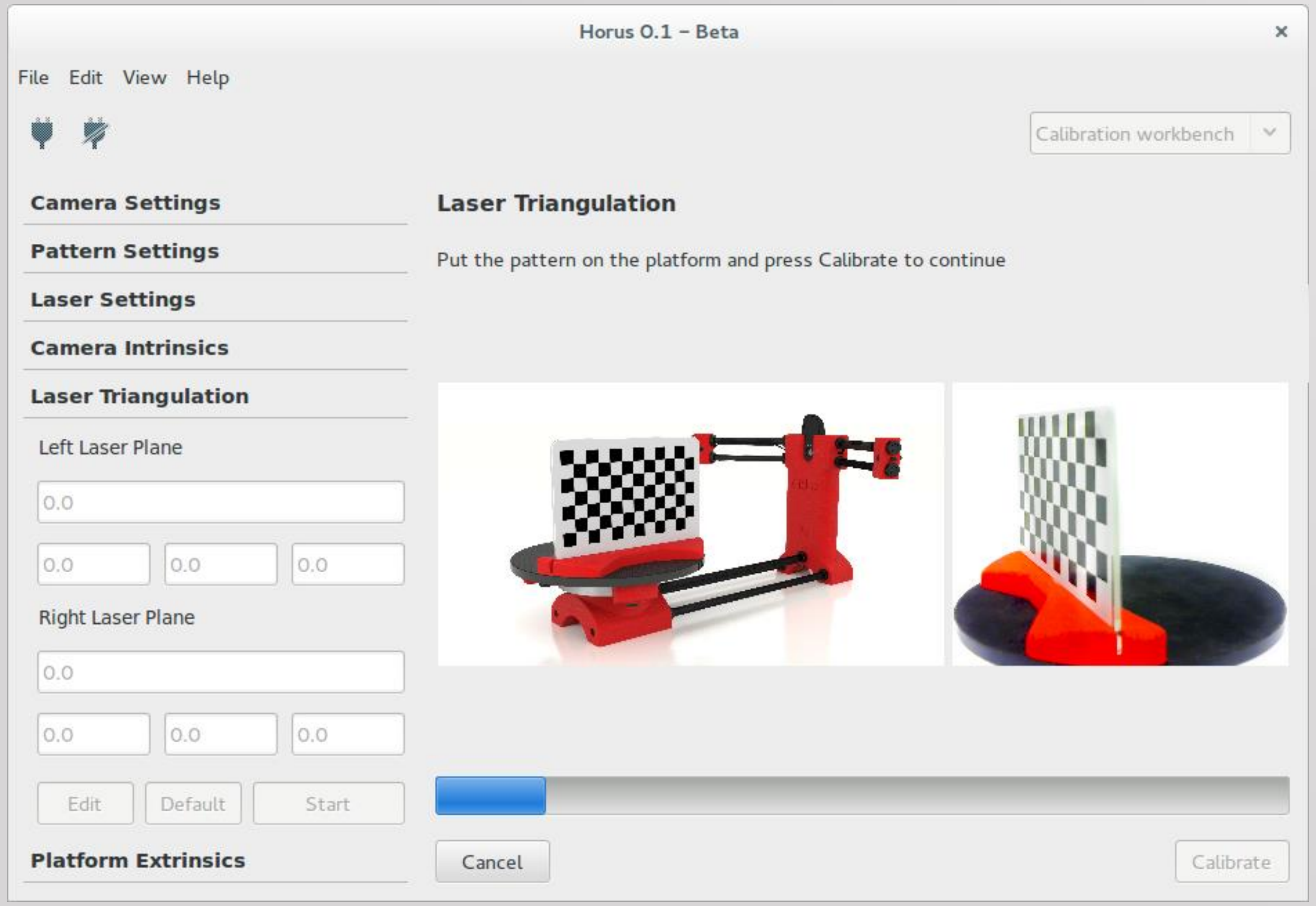
Laser Triangulation:

The aim is to calculate:

- Lasers tilt and distance from the camera to its intersection

3. Calibration Workbench

Laser Triangulation:



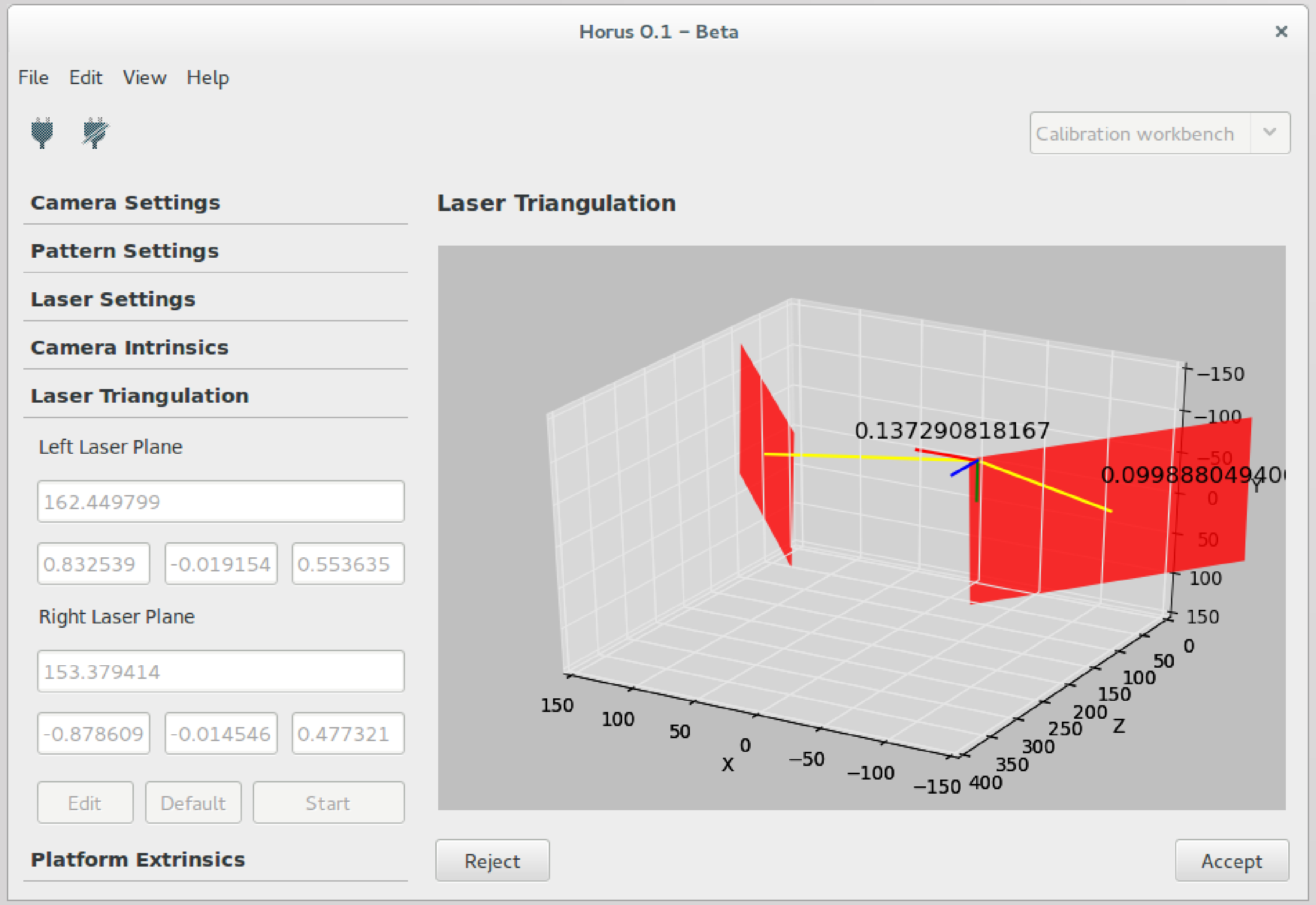
It is the second calibration process

We position the pattern as in the example

We press on Calibrate

3. Calibration Workbench

Laser Triangulation:

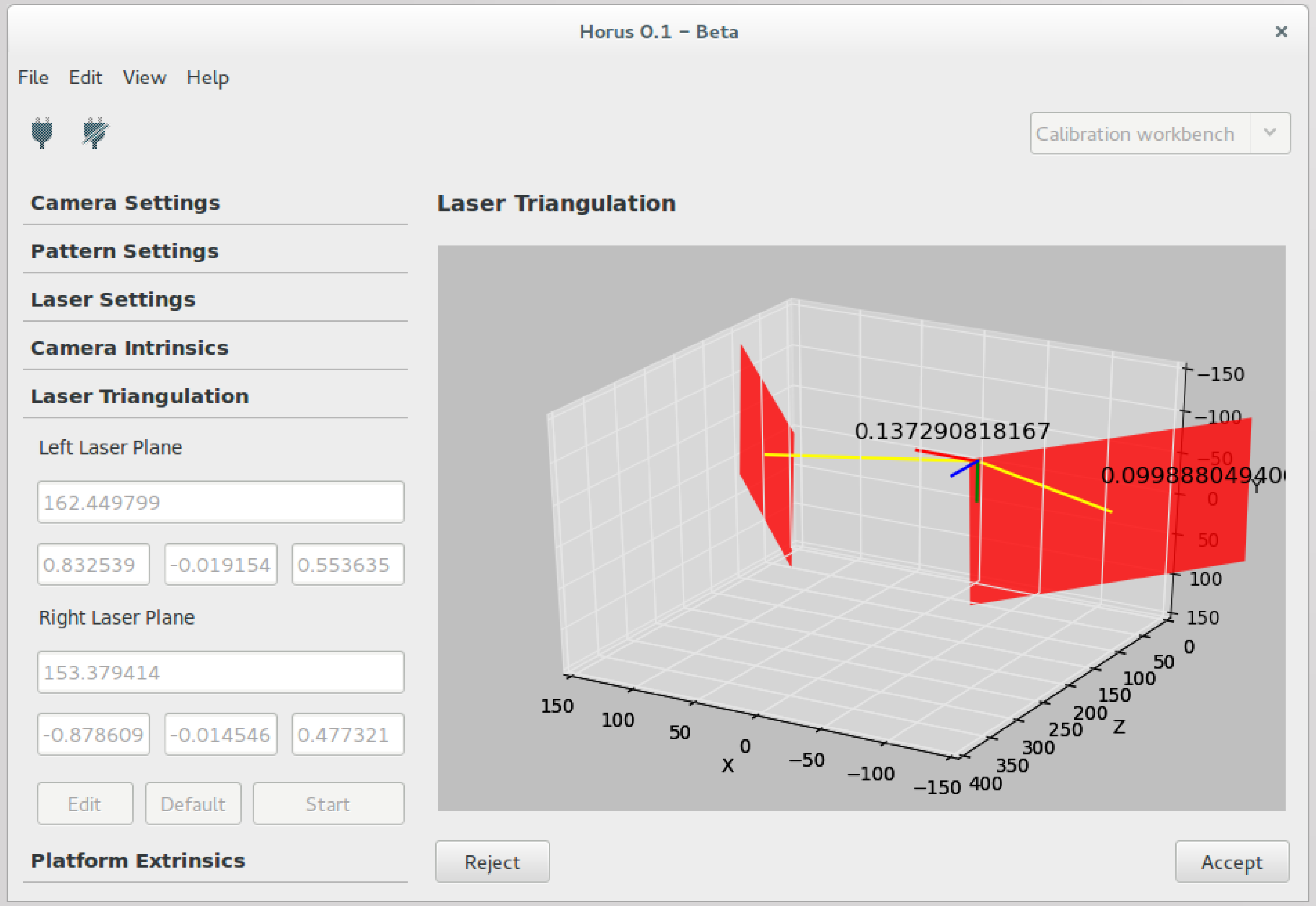


The result is displayed numerically and graphically.

At this point, to see if it is acceptable, we will discuss:

3. Calibration Workbench

Laser Triangulation:



1- Dispersion of points: Both numbers should be as close to 0.1.

2- Minimum distance from the plane to the origin: The difference should be less than 30

3. Calibration Workbench

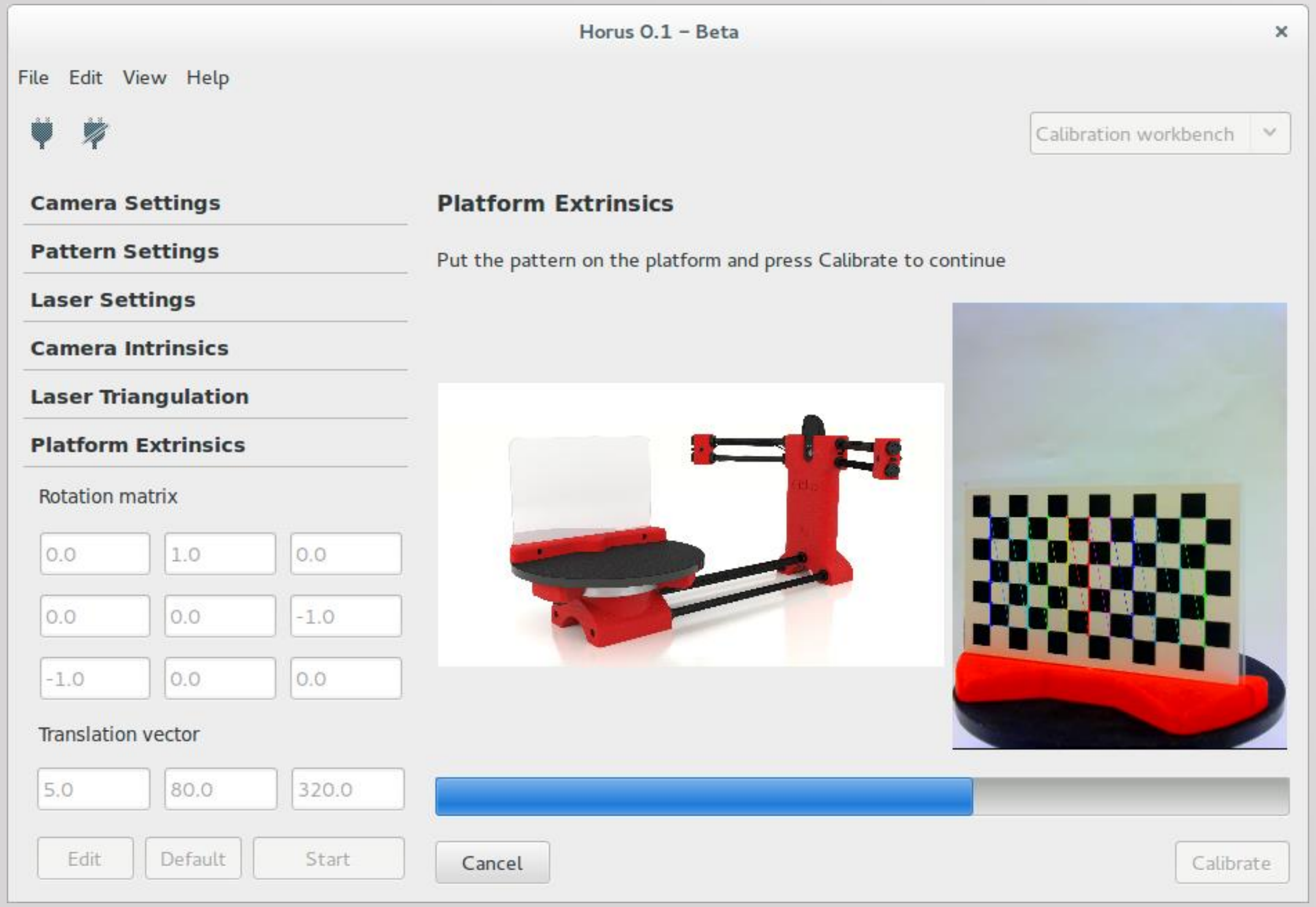
Extrinsic Calibration:

The aim is to calculate:

- The position, and rotation of the disk center or platform

3. Calibration Workbench

Extrinsic Calibration:



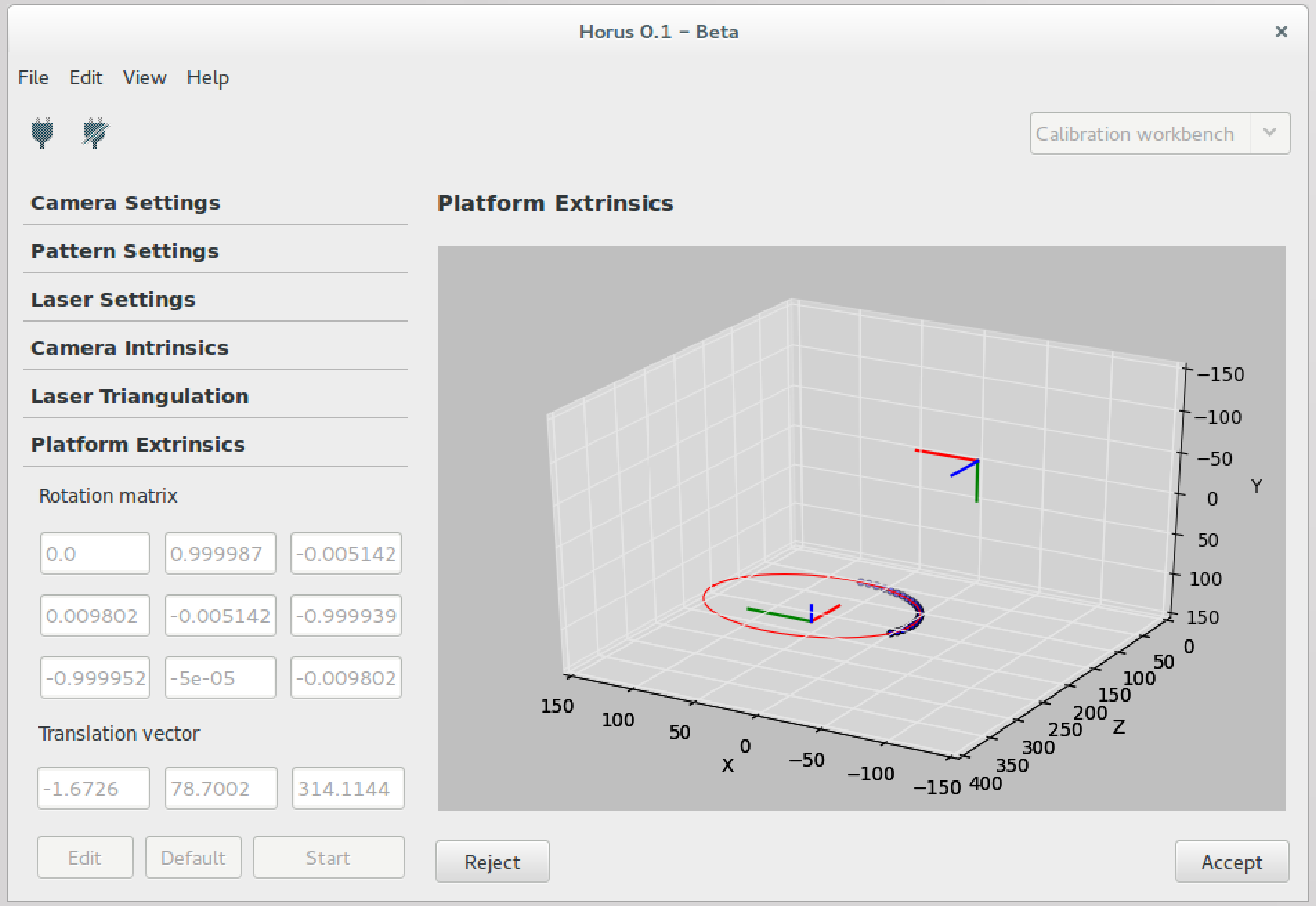
Third and last calibration

We position the pattern as in the example

We press on Calibrate

3. Calibration Workbench

Extrinsic Calibration:

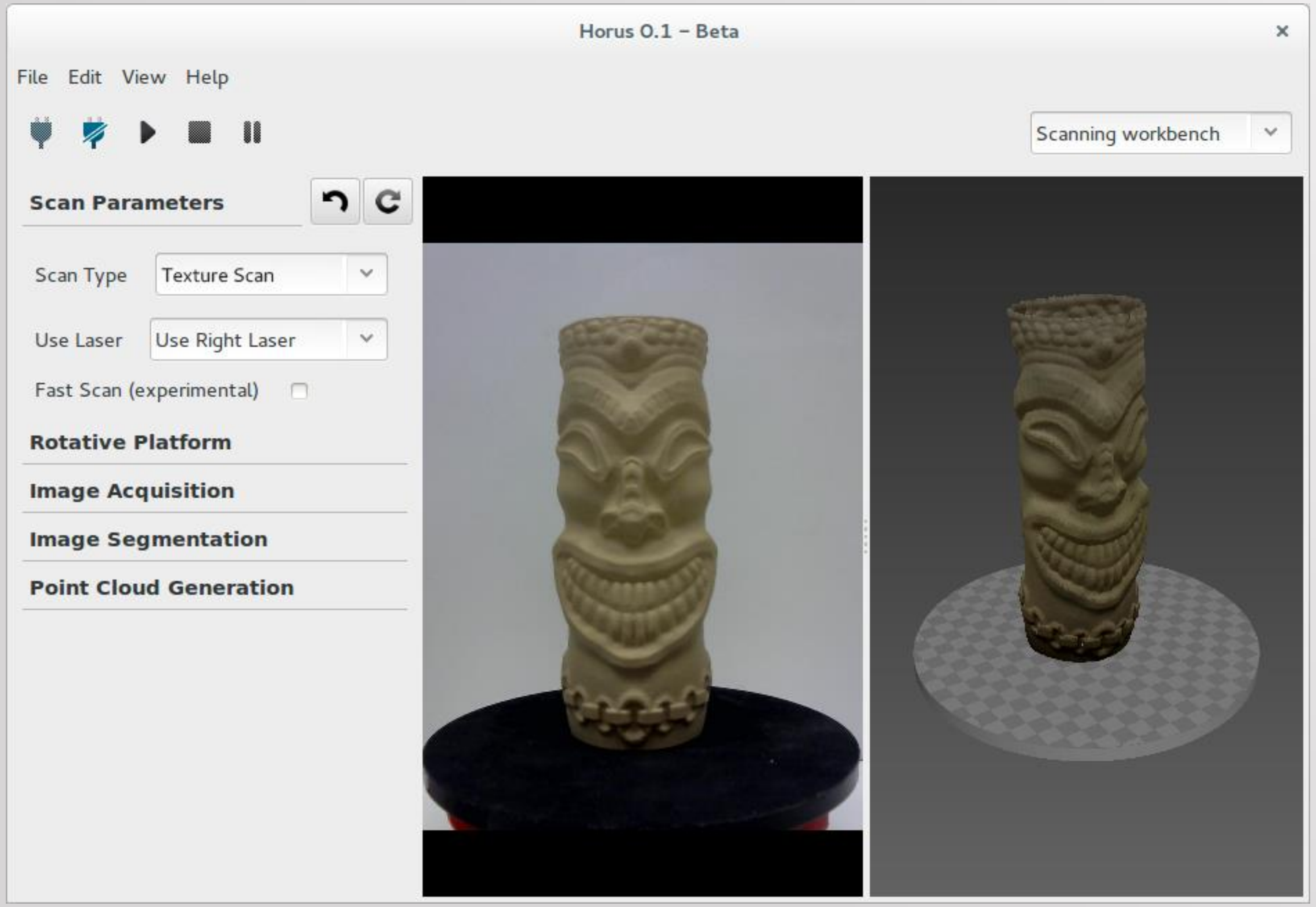


The result is displayed numerically and graphically.

At this point, we can accept or reject the calibration.

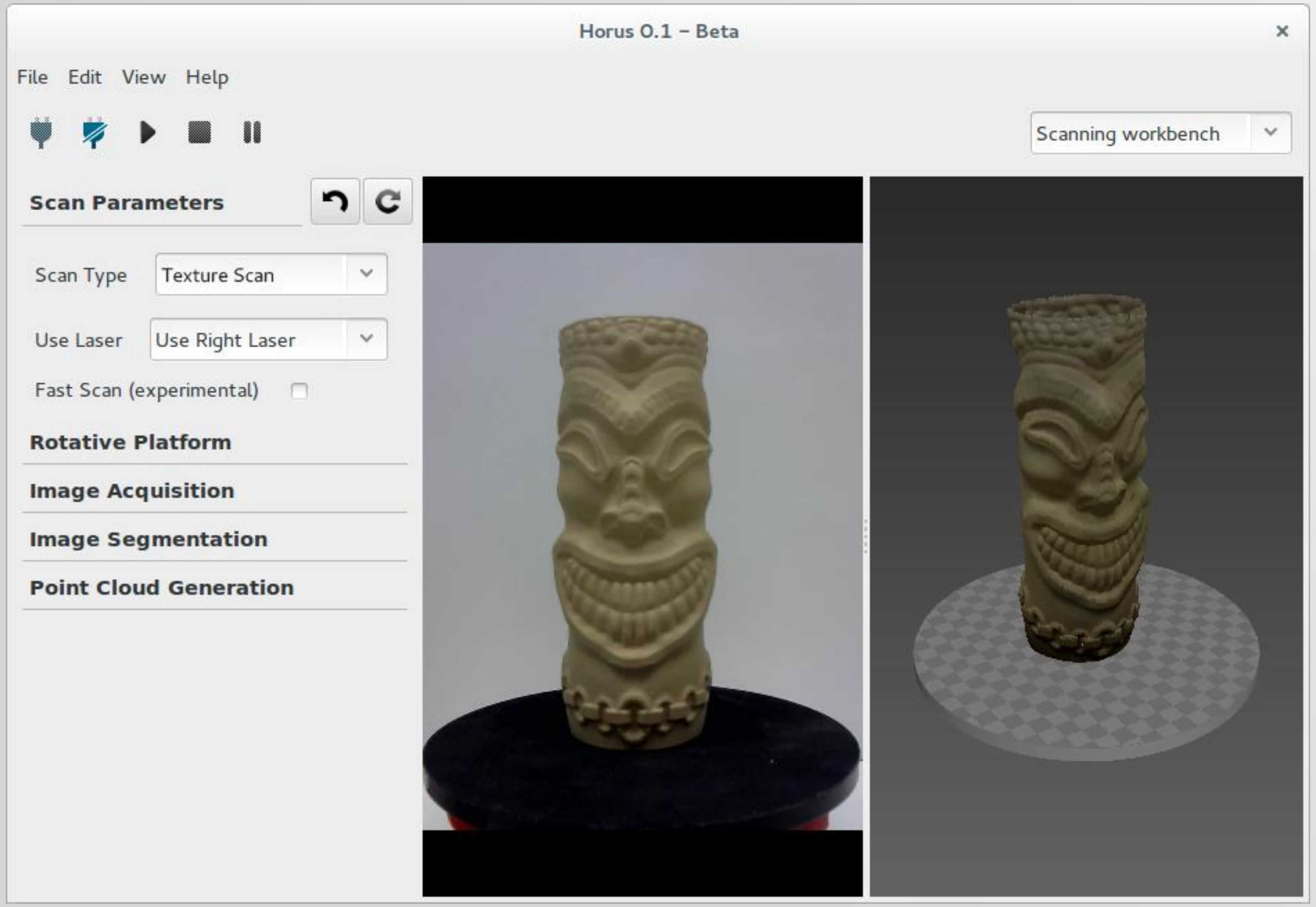
4. Scanning Workbench

Scanning and obtaining the points cloud



4. Scanning Workbench

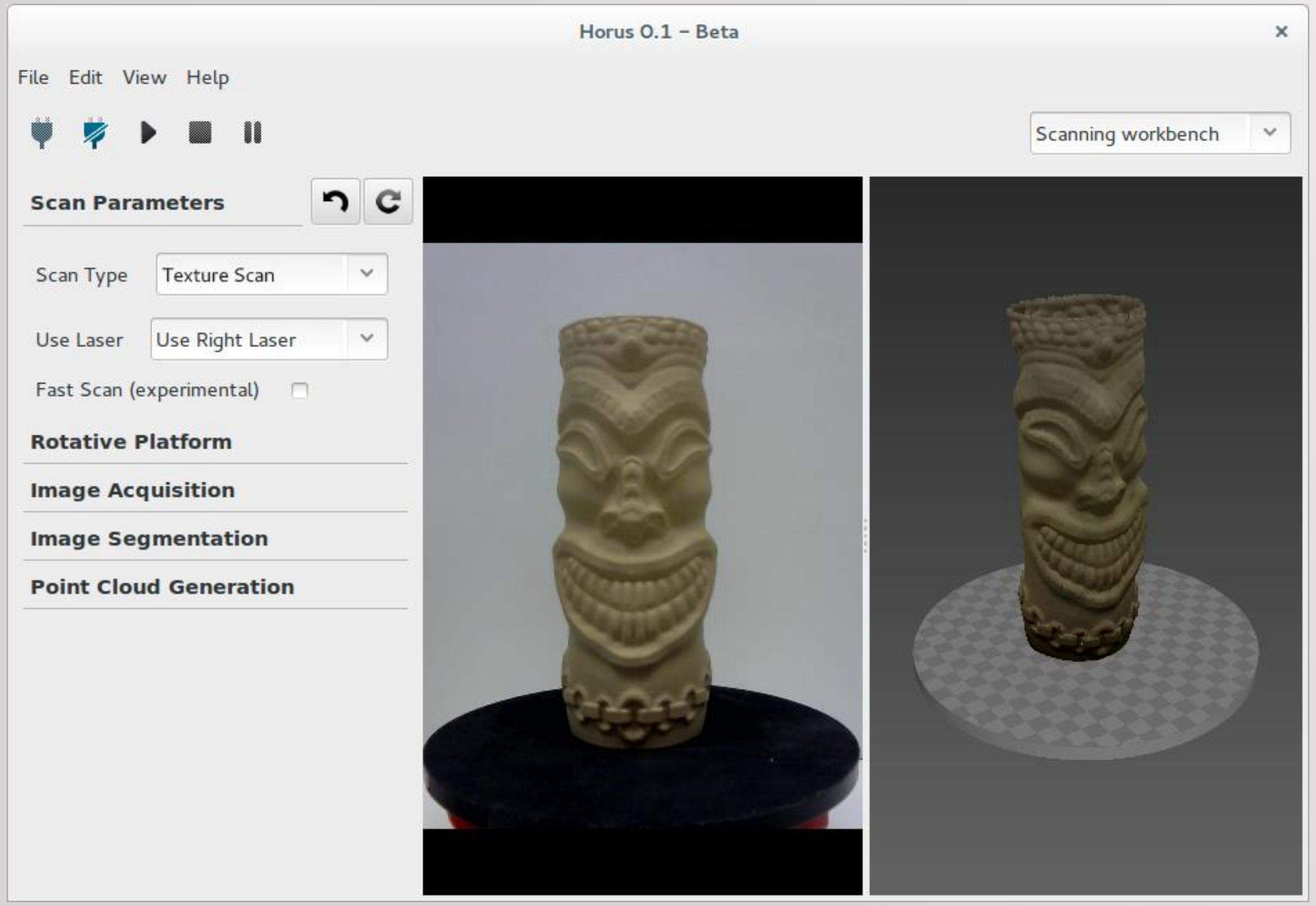
Configure the scanning options and you get the points cloud



4. Scanning Workbench

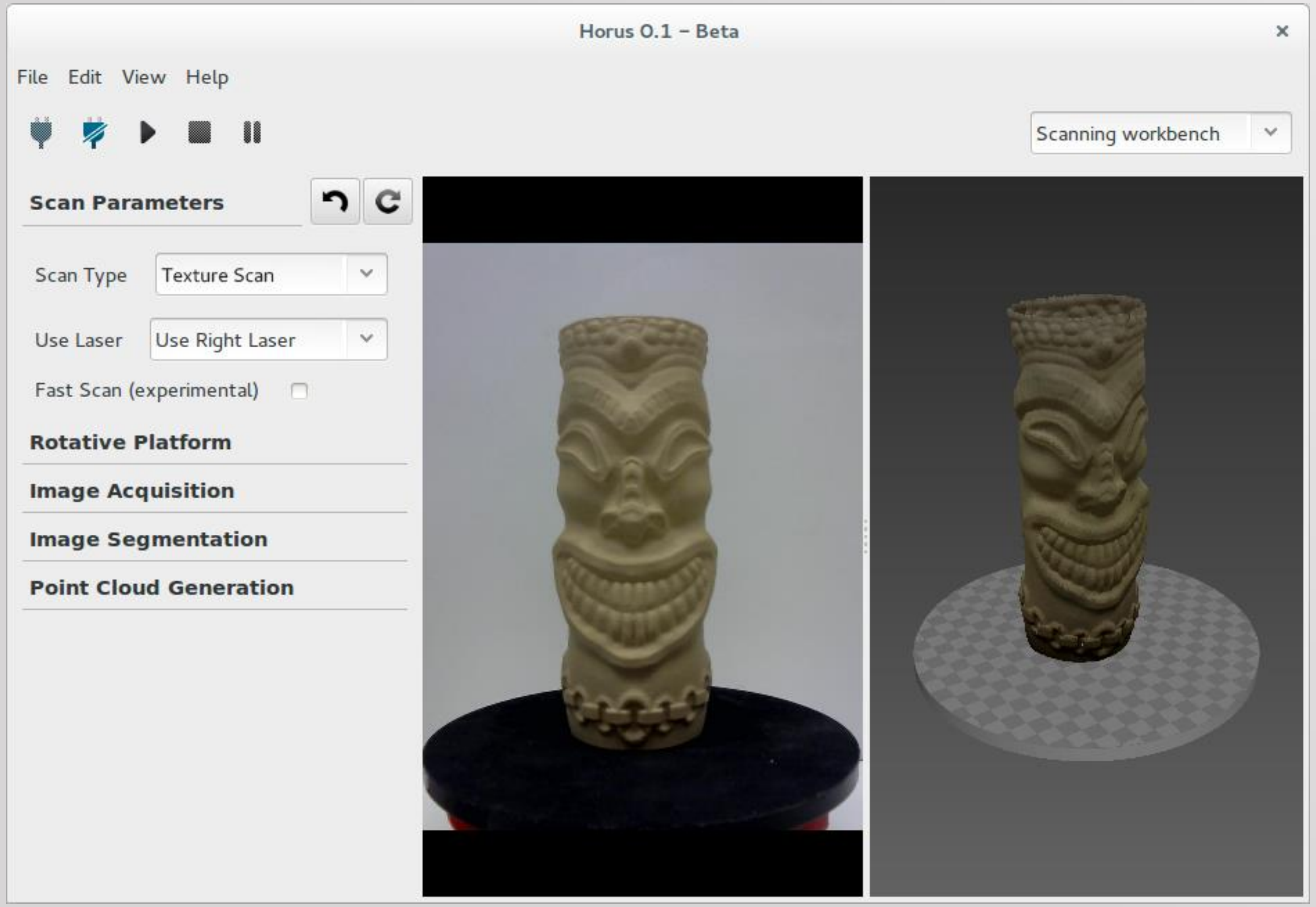
Settings panel

Scan Type: Without Texture / With Texture. In the second case, the real color of the piece is captured



4. Scanning Workbench

Settings panel

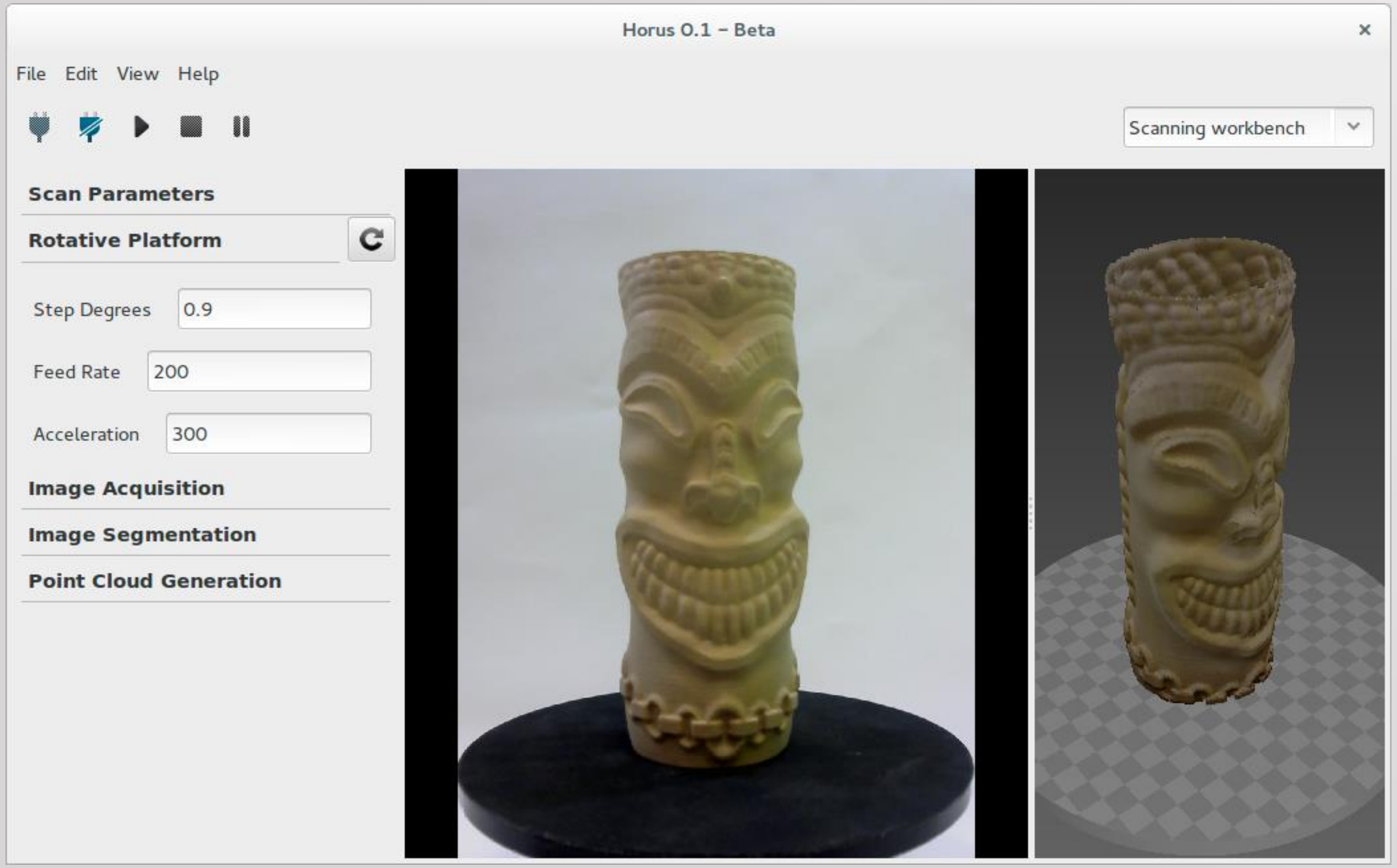


- Using laser: Left, right, or both.

  Using both, you'll get more information, but should make a more accurate calibration for better results.

4. Scanning Workbench

Settings panel

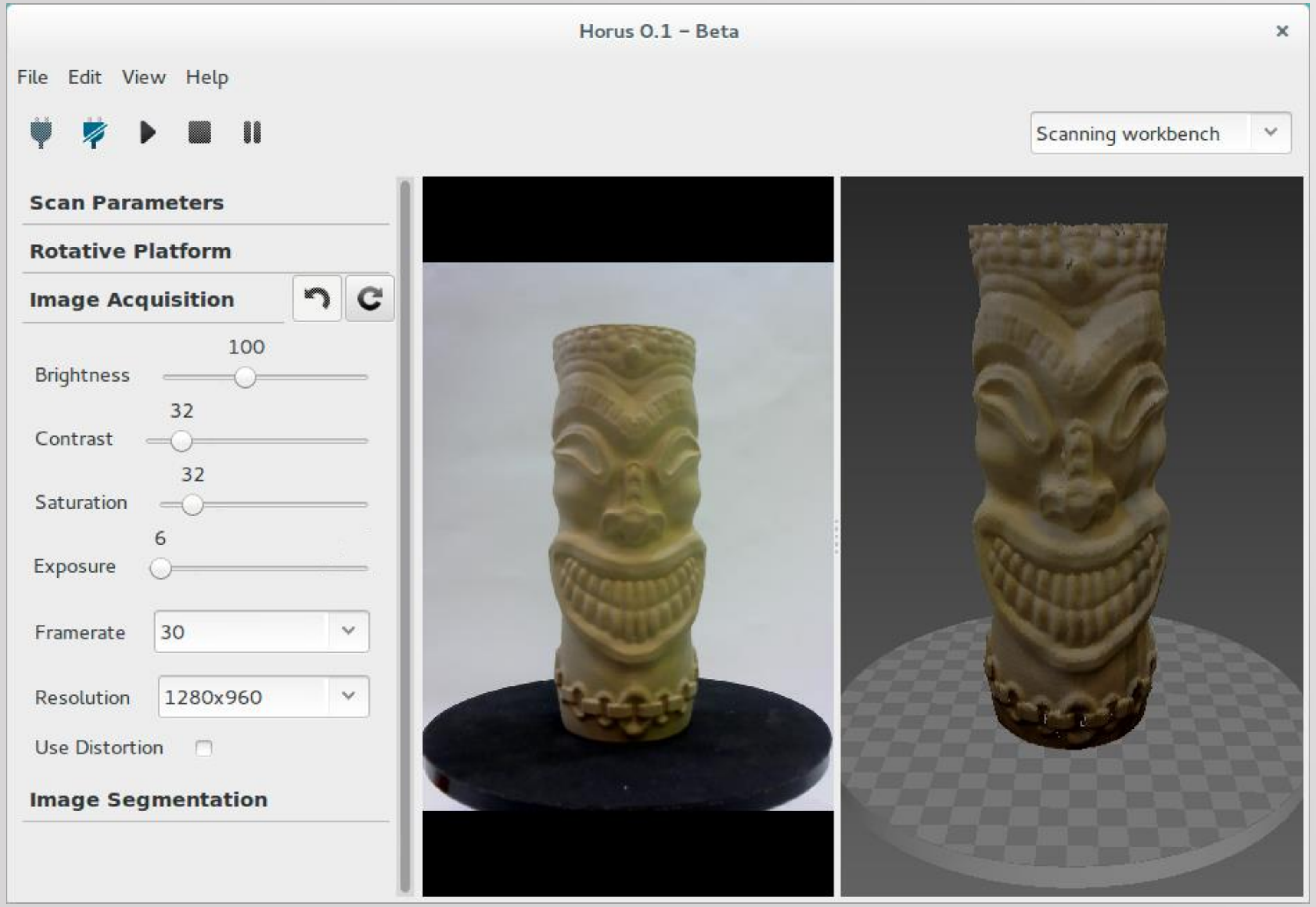


- Motor parameters, speed and acceleration.

  A small or minimum step, 0,45º for example, generates higher points density.

4. Scanning Workbench

Settings panel

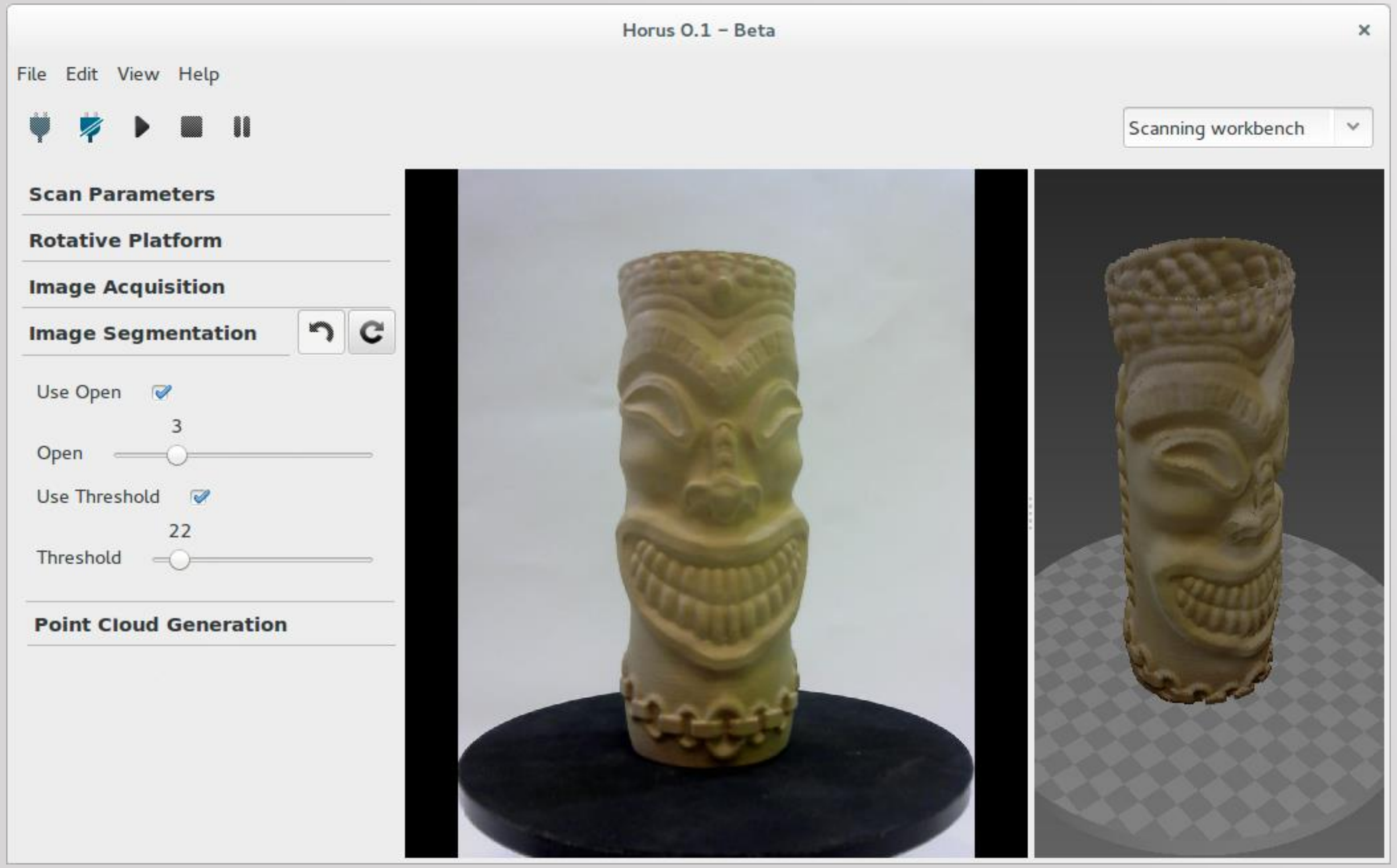


- Image acquisition: Brightness, contrast, saturation, exposure...

  They are the same parameters as in the Calibration Workbench.

4. Scanning Workbench

Settings panel

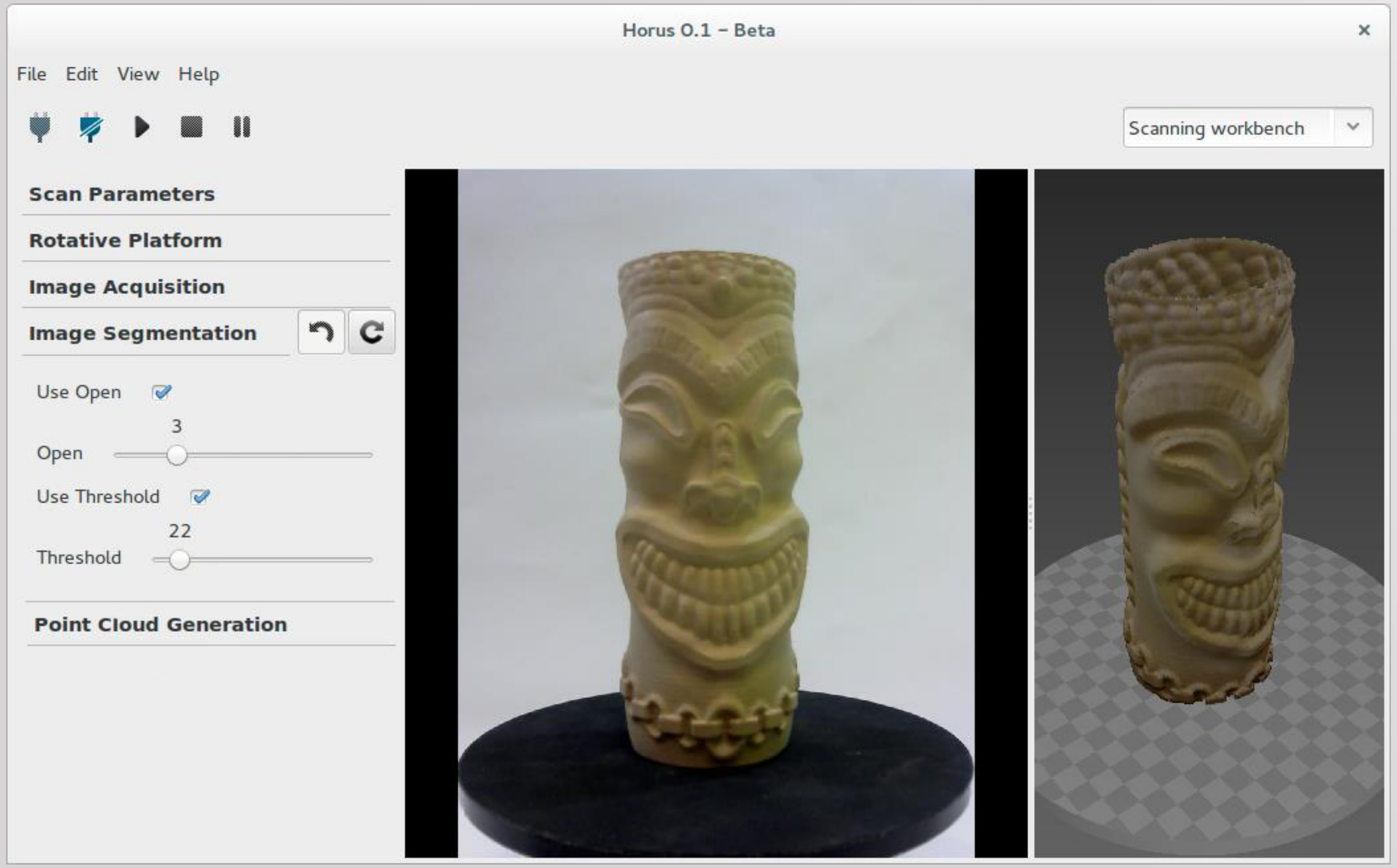


- Image segmentation.

  Applying a filter. Noise is removed above the desired value (threshold), but the cloud will have less detail.

4. Scanning Workbench

Settings panel

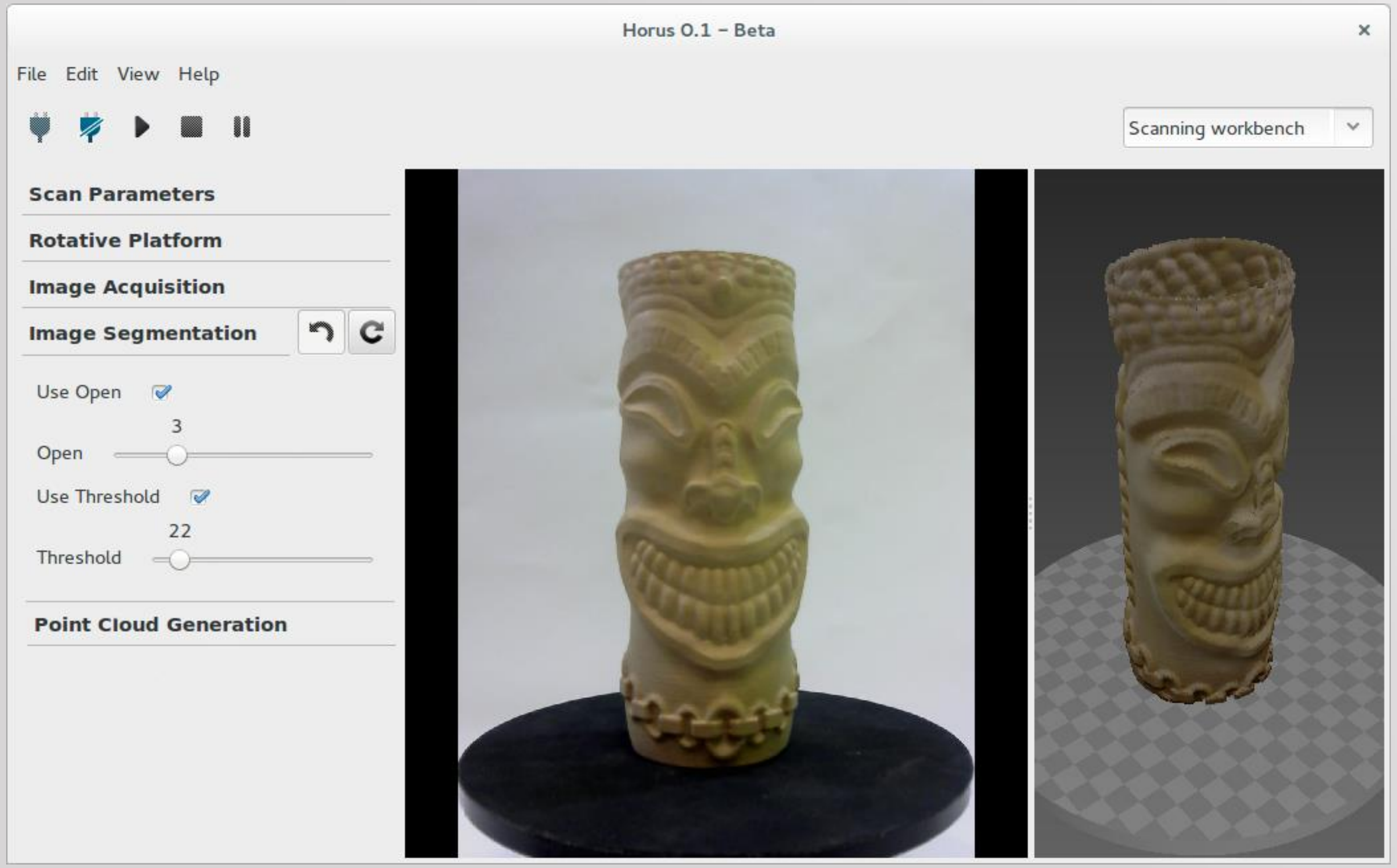


- Image segmentation.

  For simple texture or without scanning, can be used threshold.

4. Scanning Workbench

Settings panel

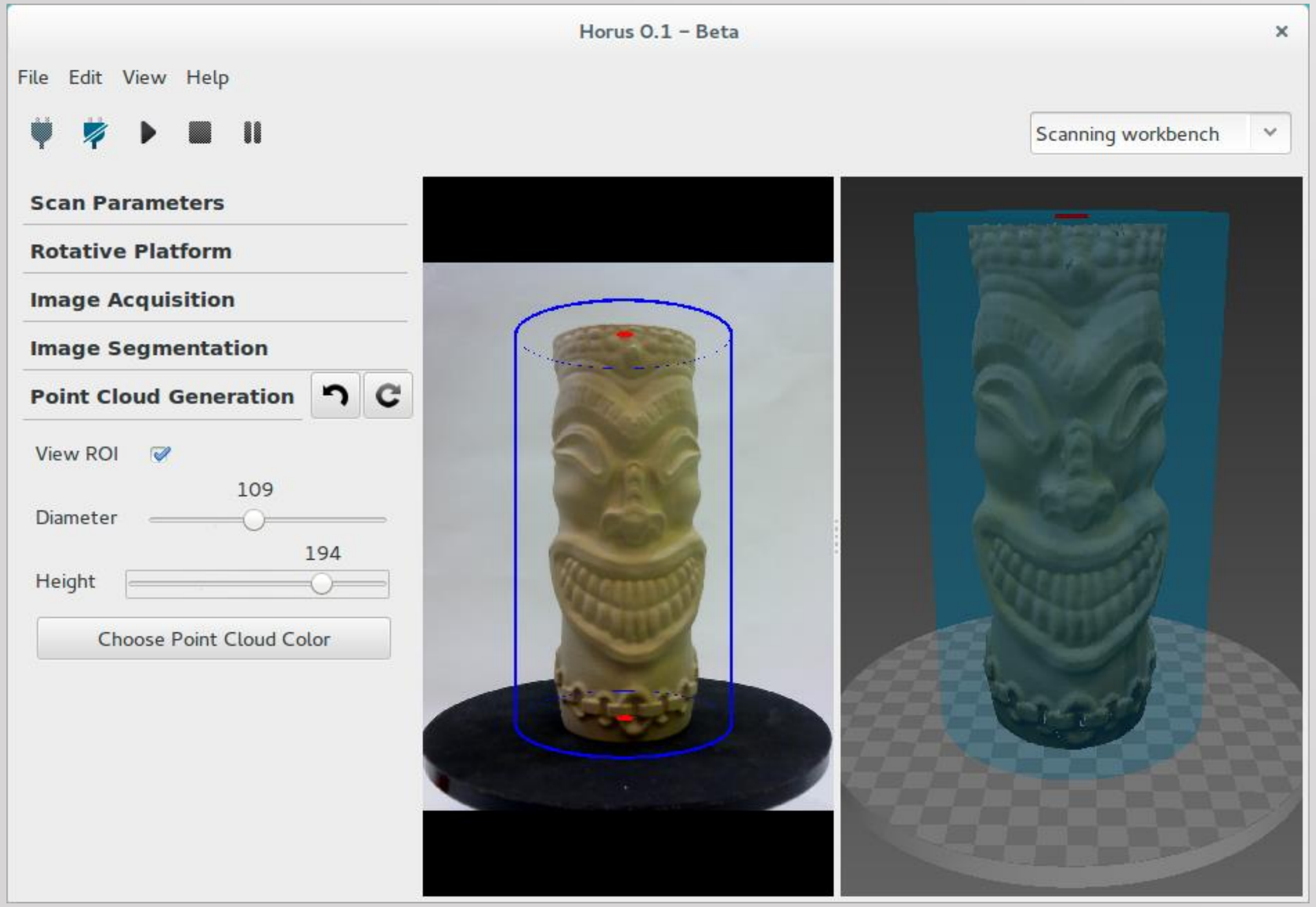


- Image segmentation.

  For Scanning with texture, you also can use Open, and the removing noise intensifies.

4. Scanning Workbench

Settings panel



- ROI: Creating an area of interest.

  It will be scanned only within the cylinder, avoiding obtaining noise from outer areas.

4. Scanning Workbench

Settings panel

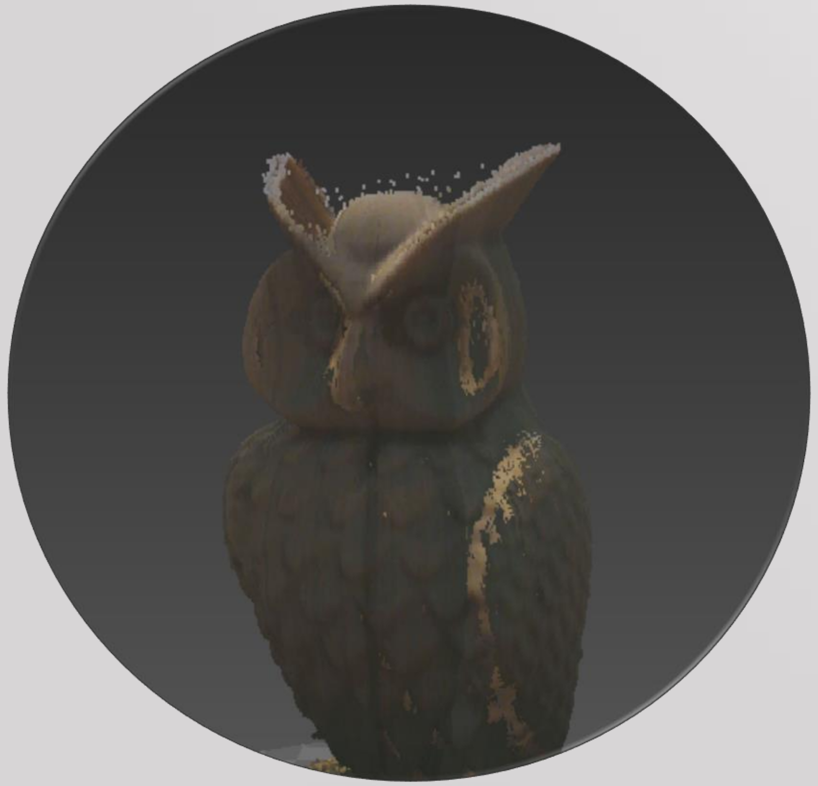
To scan, press in the PLAY icon

Once finished, to save the point cloud will click on File > Save Model

The output format will be .PLY

Meshlab

Step Two: Reconstruction of the point cloud



1. Cleaning the Cloud

2. Calculation of normal vectors

3. Poisson Reconstruction

4. Joining clouds (optional)

5. Smoothing the .STL (optional)

1. Cleaning the Cloud

bq

Cloud cleaning is use to remove those points that do not want, because they are noise, or do not interest us

1. Cleaning the Cloud

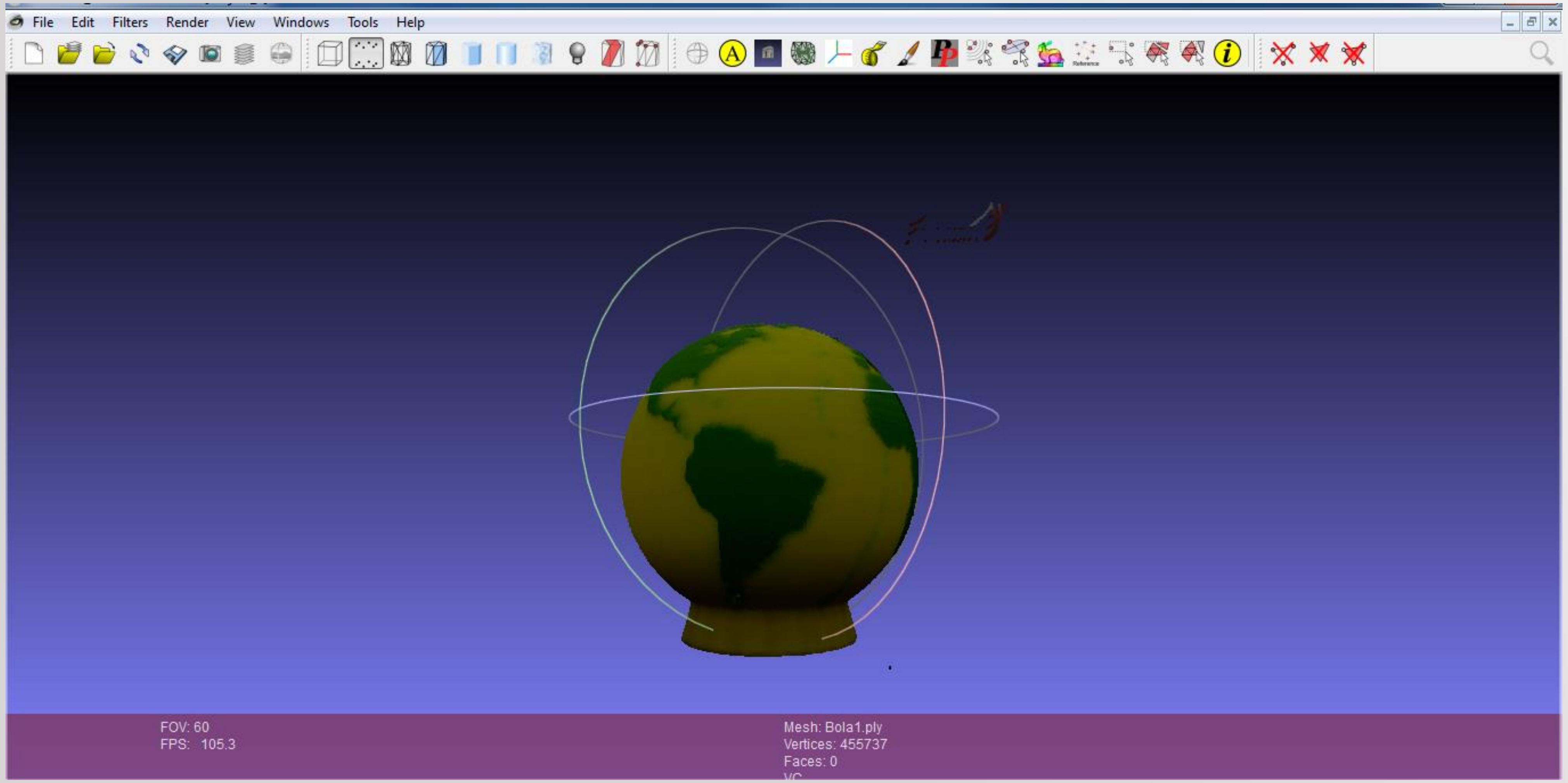
bq

To do this, we open the point cloud format .PLY

File > Import mesh

1. Cleaning the Cloud

We must open the point cloud in .PLY format



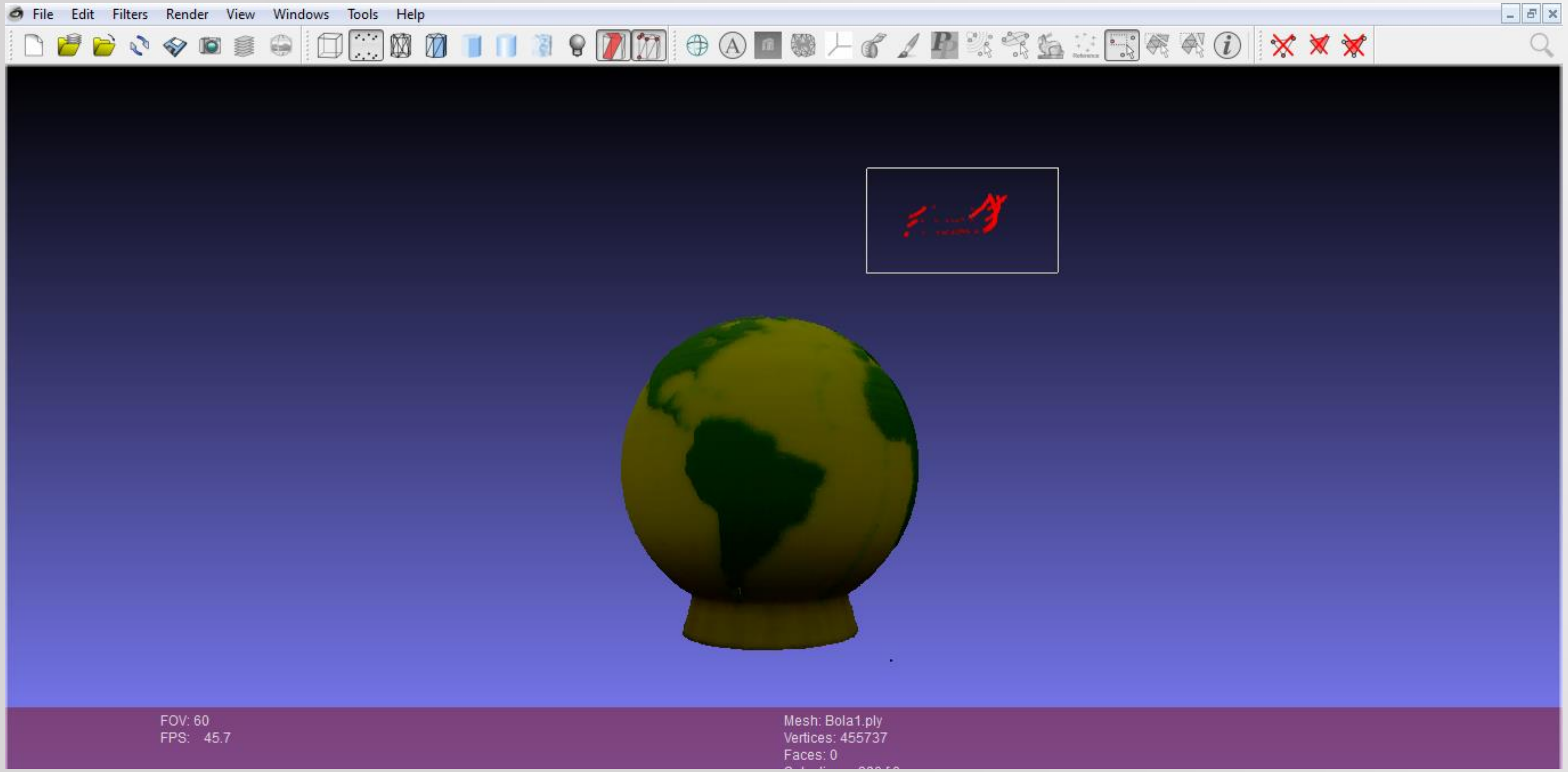
1. Cleaning the Cloud

bq

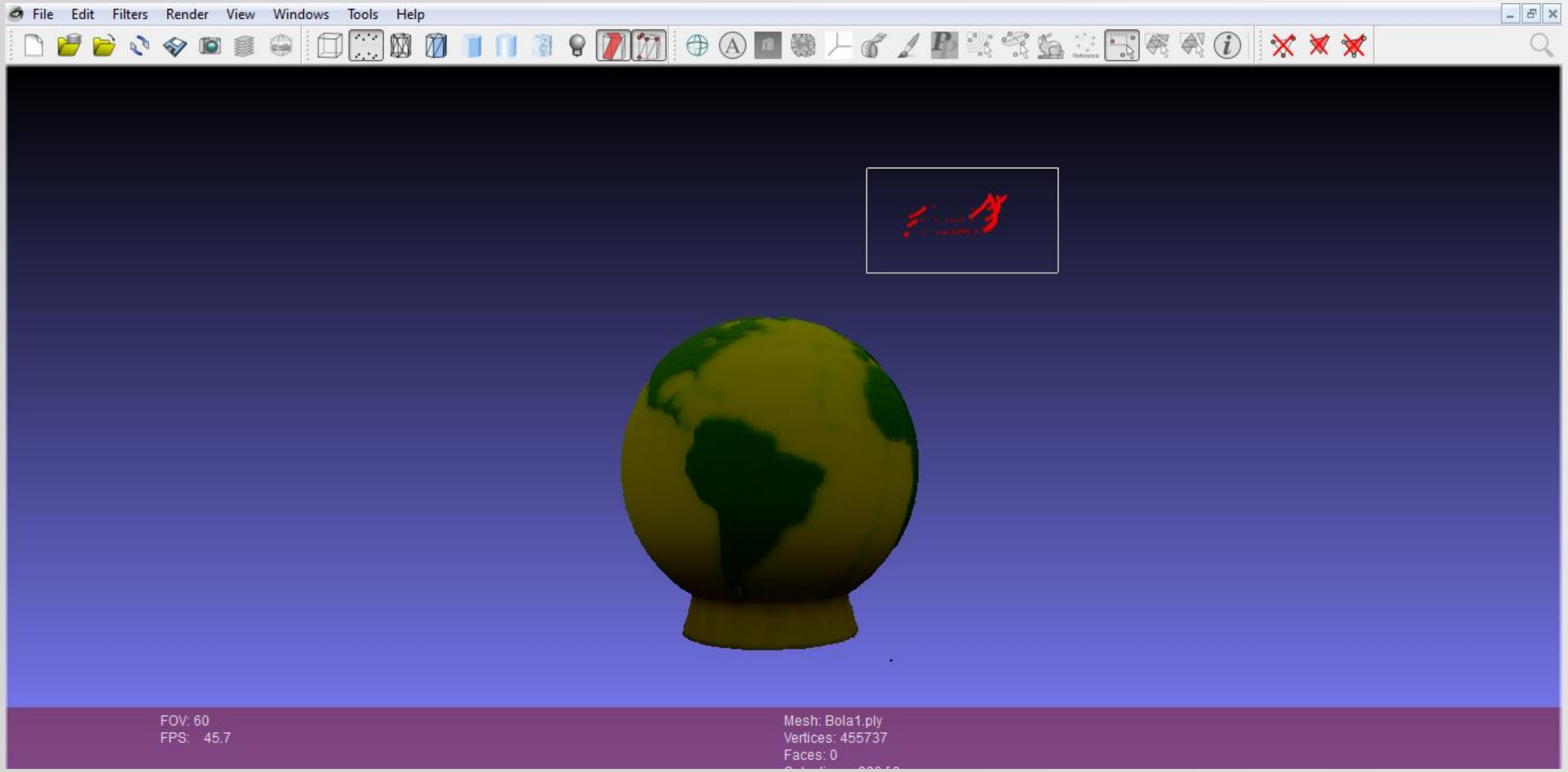
To delete points, select the *Vertex Select* tool

Then we choose the unwanted points. They are displayed in red

1. Cleaning the Cloud

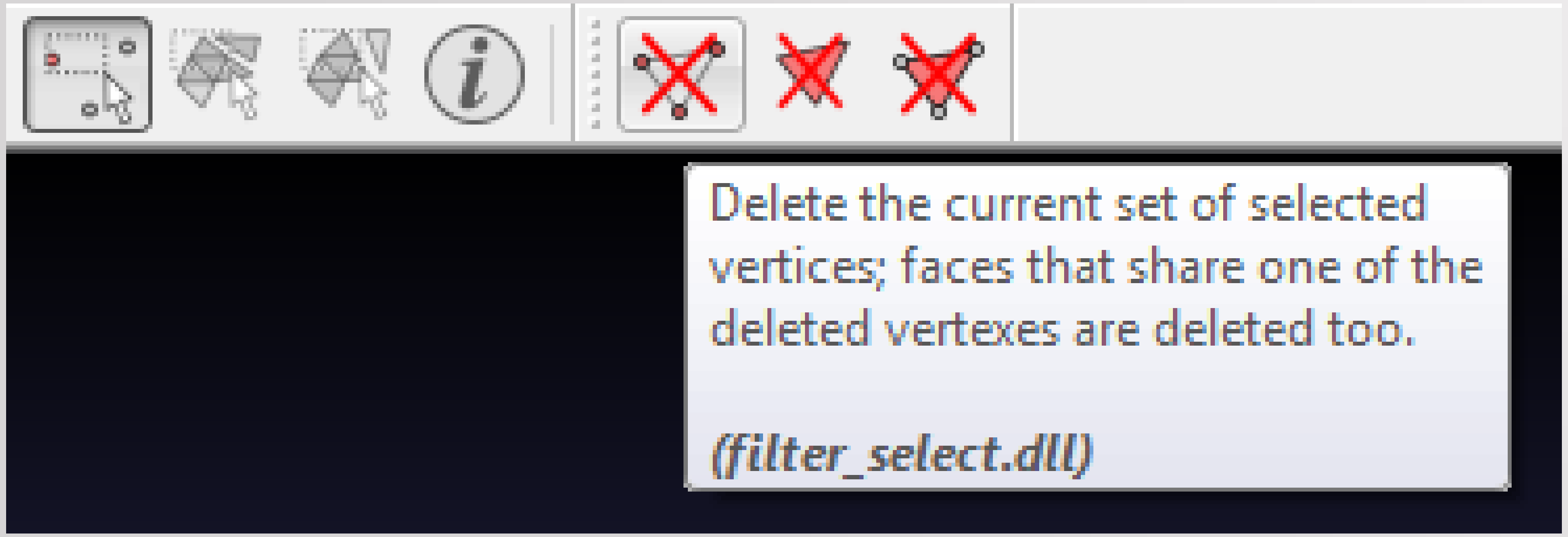


1. Cleaning the Cloud



1. Cleaning the Cloud

Then select the option *Delete selected vertices* of the toolbar

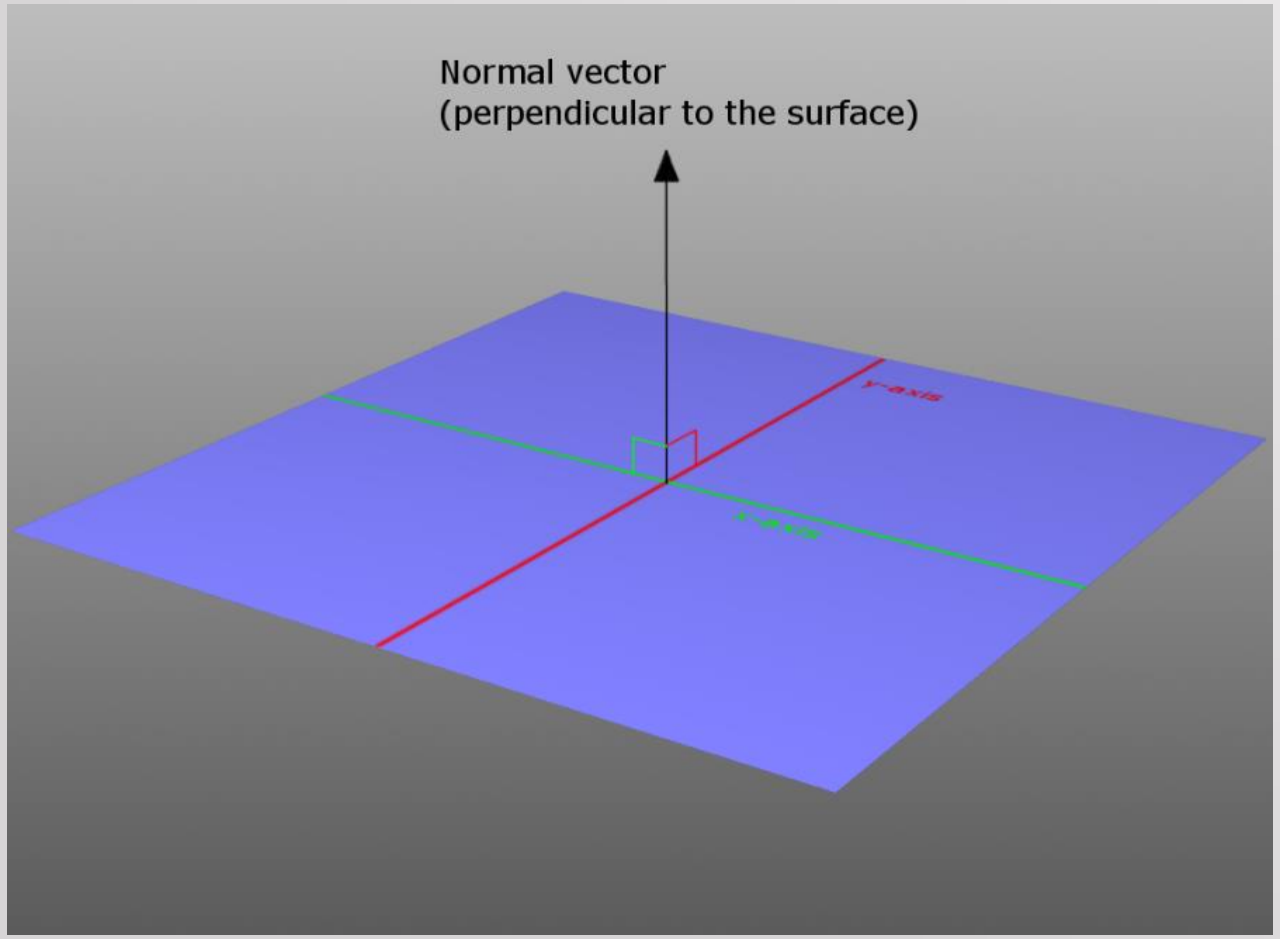


1. Cleaning the Cloud

A cleaned cloud points will be very important to obtain a good result

2. Calculation of normal vectors

A normal is a perpendicular vector to a plane

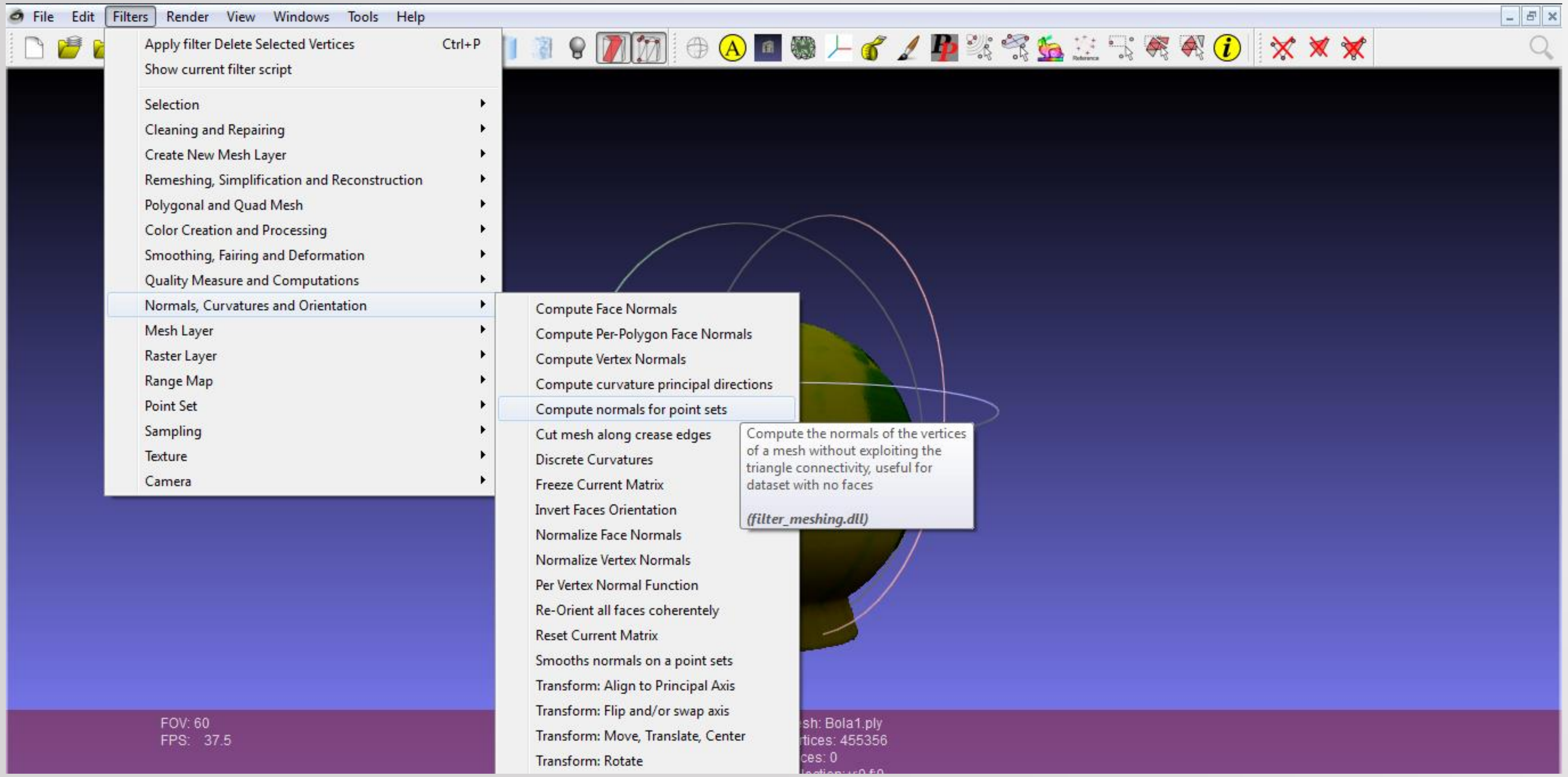


2. Calculation of normal vectors

In this step, we will calculate the normal of the points cloud.

To do this, we group a number of points to form a plane, and finally the average is calculated.

2. Calculation of normal vectors

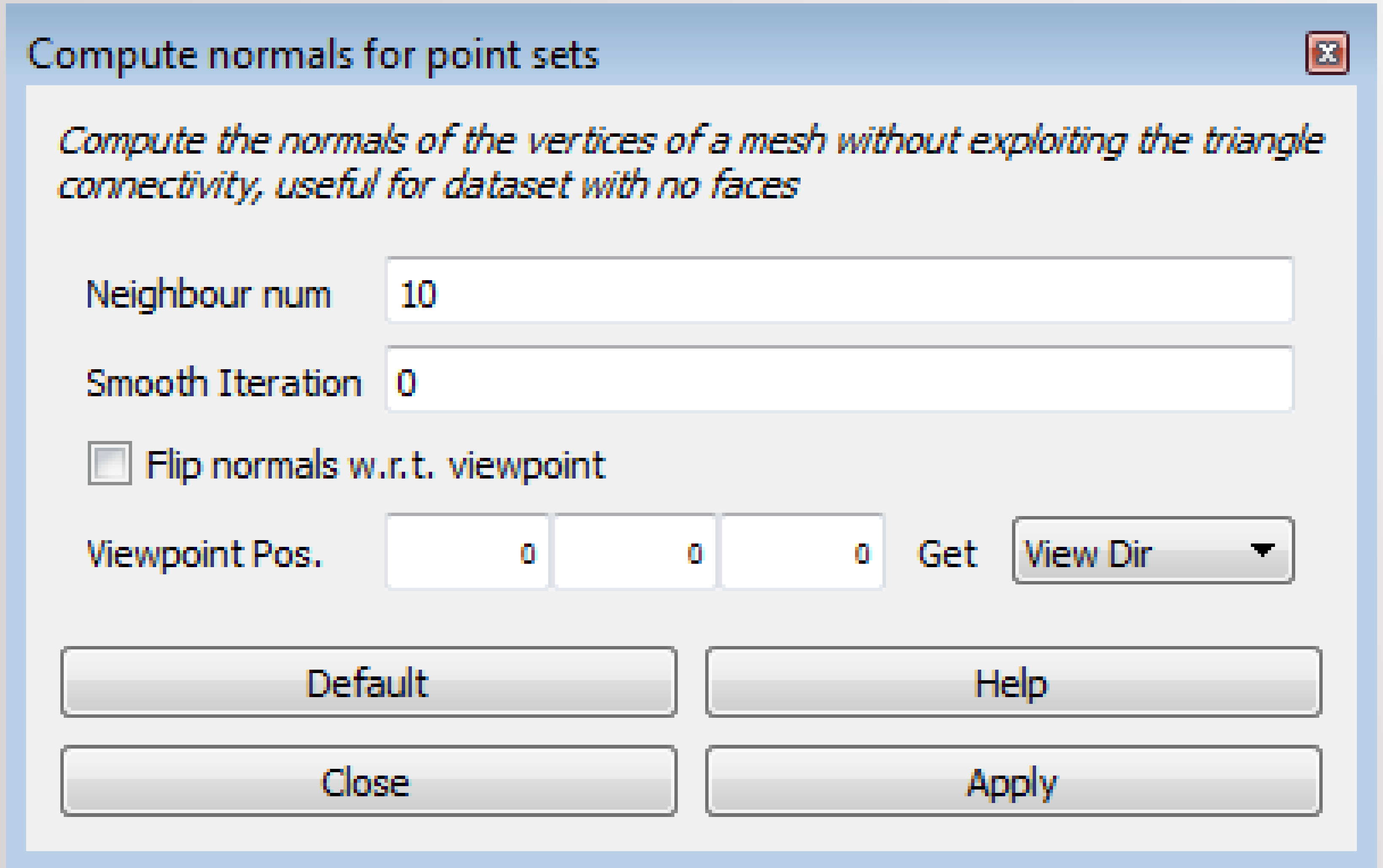


2. Calculation of normal vectors

Now we calculate the number of neighbors. Determines the amount of points needed to create a vector.

It is recommended to start with a value of 10. The other values will be left by default. Then, we apply it.

2. Calculation of normal vectors



2. Calculation of normal vectors

We show normal. The best reconstructions are when the direction of the vectors are oriented away from the object.

If the normal vectors are not directed outwards, we repeat the step changing the number of neighbors to 50; if repeated, 100.

2. Calculation of normal vectors

Number of neighbors: 10

Number of neighbors: 50

3. Poisson Reconstruction

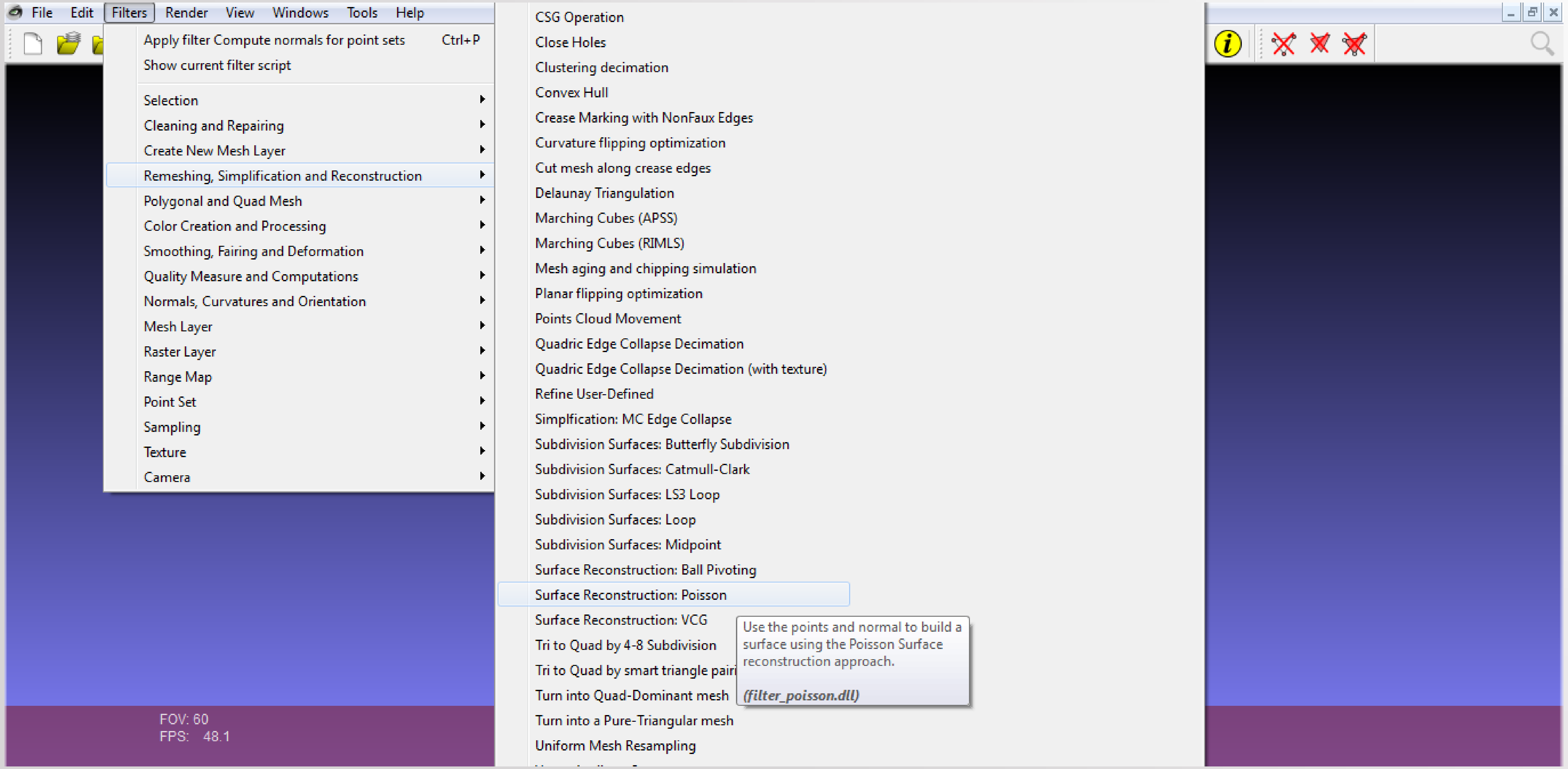
For the reconstruction, we convert from .PLY to .STL

It is a critical step, because depending on the previously established normal and reconstruction values, the STL may vary.

3. *Poisson Reconstruction*

To do this, we choose the option *Poisson Reconstruction*

3. Poisson Reconstruction



3. Poisson Reconstruction

In this window you can modify two values:

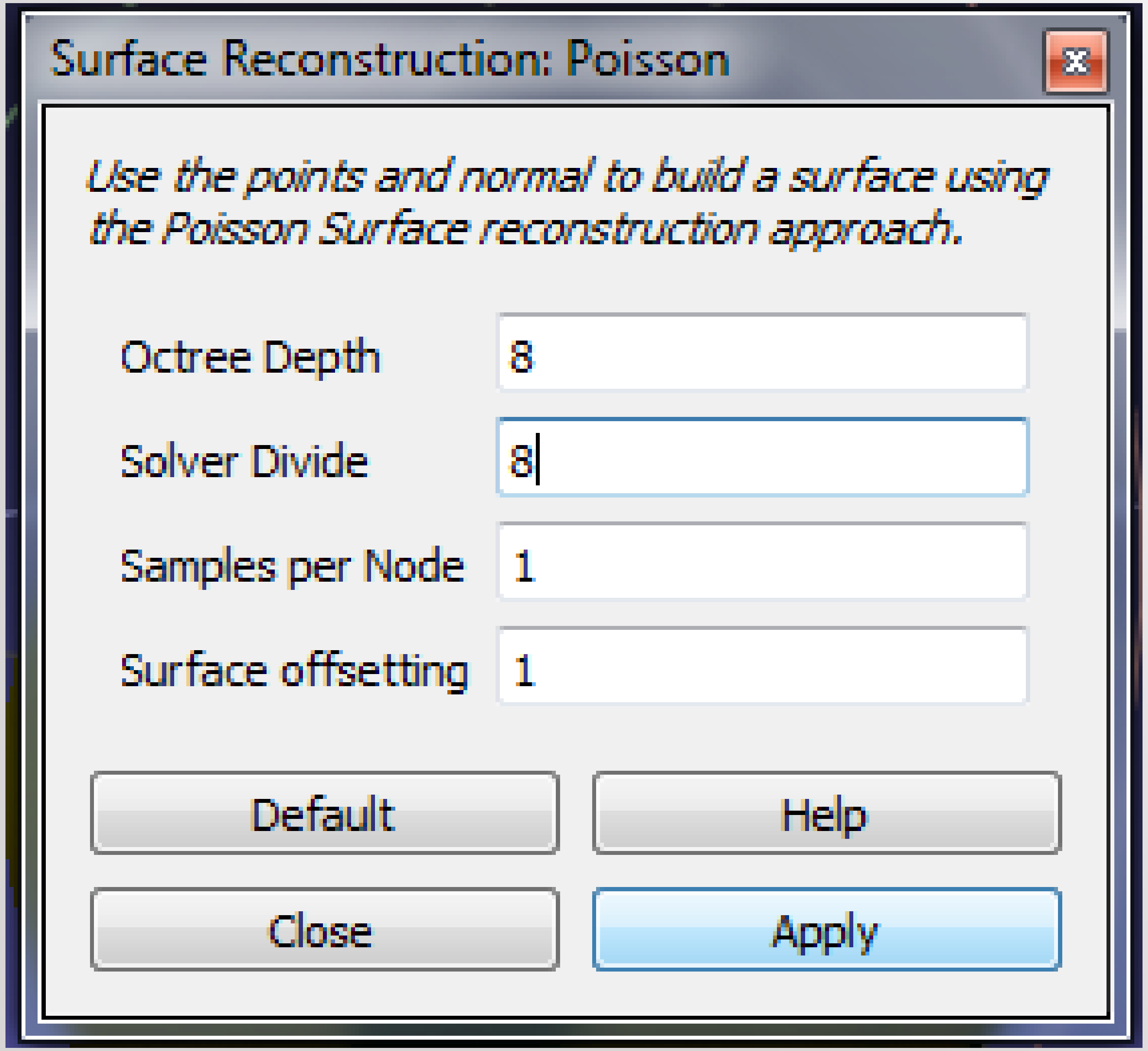
- Octree Depth
- Solver Divide

3. Poisson Reconstruction

The recommended values of both parameters are between 6 and 11.

With a higher the value, the reconstruction is more accurate, but it takes longer to make the process.

3. Poisson Reconstruction

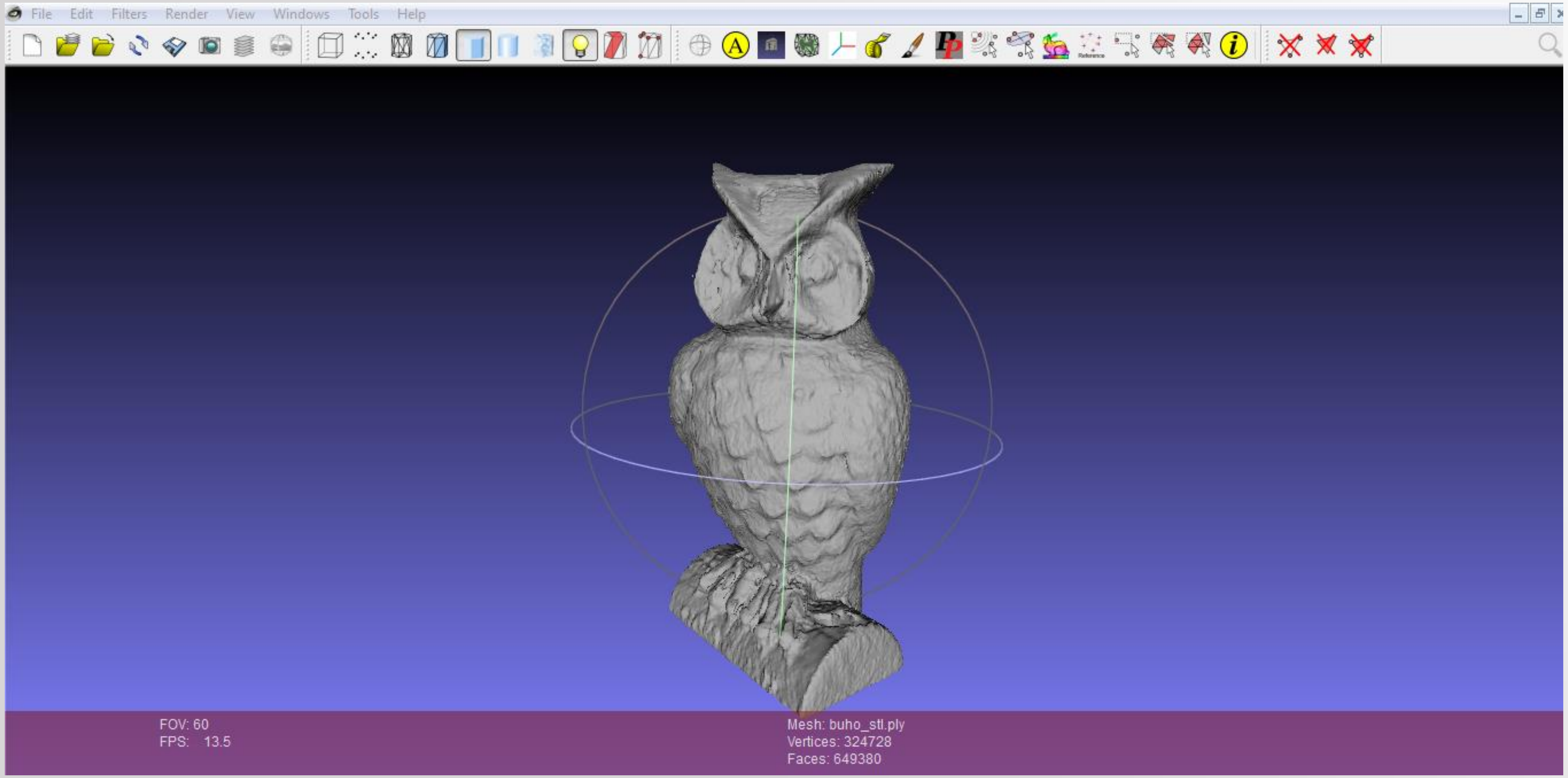


3. Poisson Reconstruction

To view reconstruction:

View > Show Layer Dialog

3. Poisson Reconstruction



3. Poisson Reconstruction

To save the reconstruction (STL):

File > Export Mesh...

3. Poisson Reconstruction

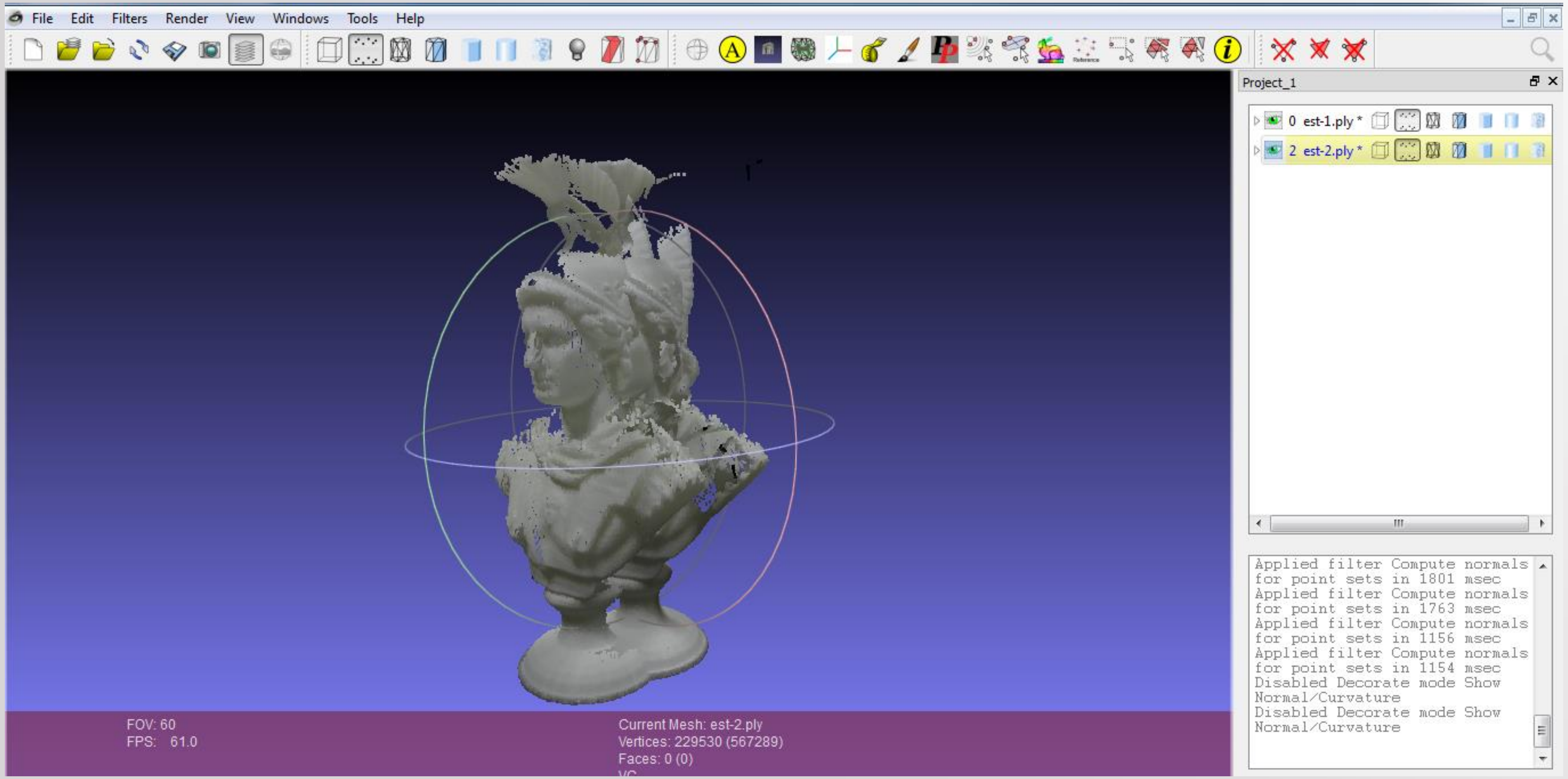
Sometimes due to the geometry of the piece, the cloud of points are incomplete.

To fix this, you can re-scan the piece in another position or by using another laser, and then join the different clouds.

4. Joining clouds (optional)

To do this, we will open the various .PLY in MeshLab

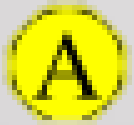
4. Joining clouds (optional)



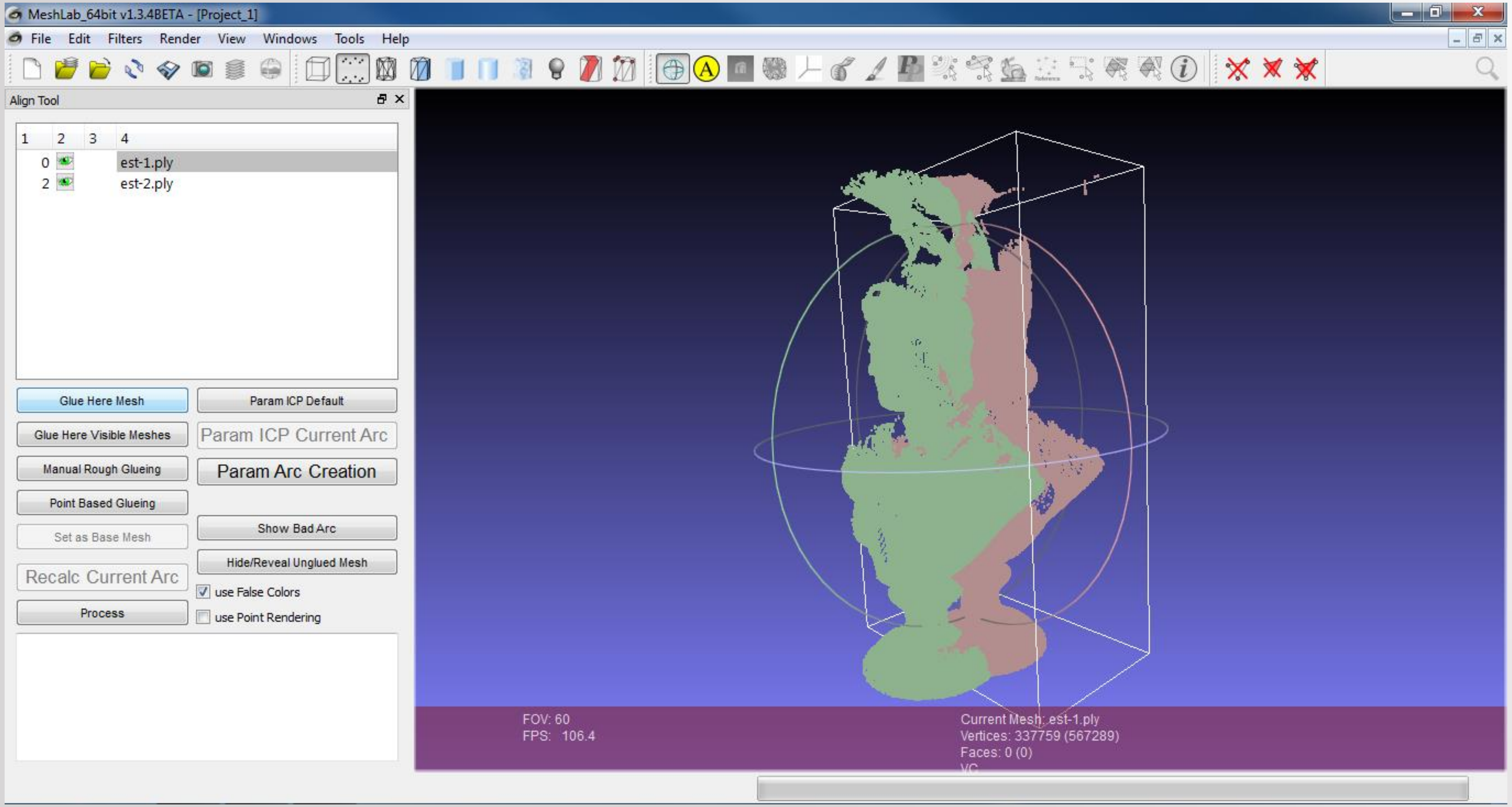
4. Joining clouds (optional)

In the *Layer Dialog*, we calculate each normal point cloud, as described above.

Once done, we click on the *Align* tool



4. Joining clouds (optional)

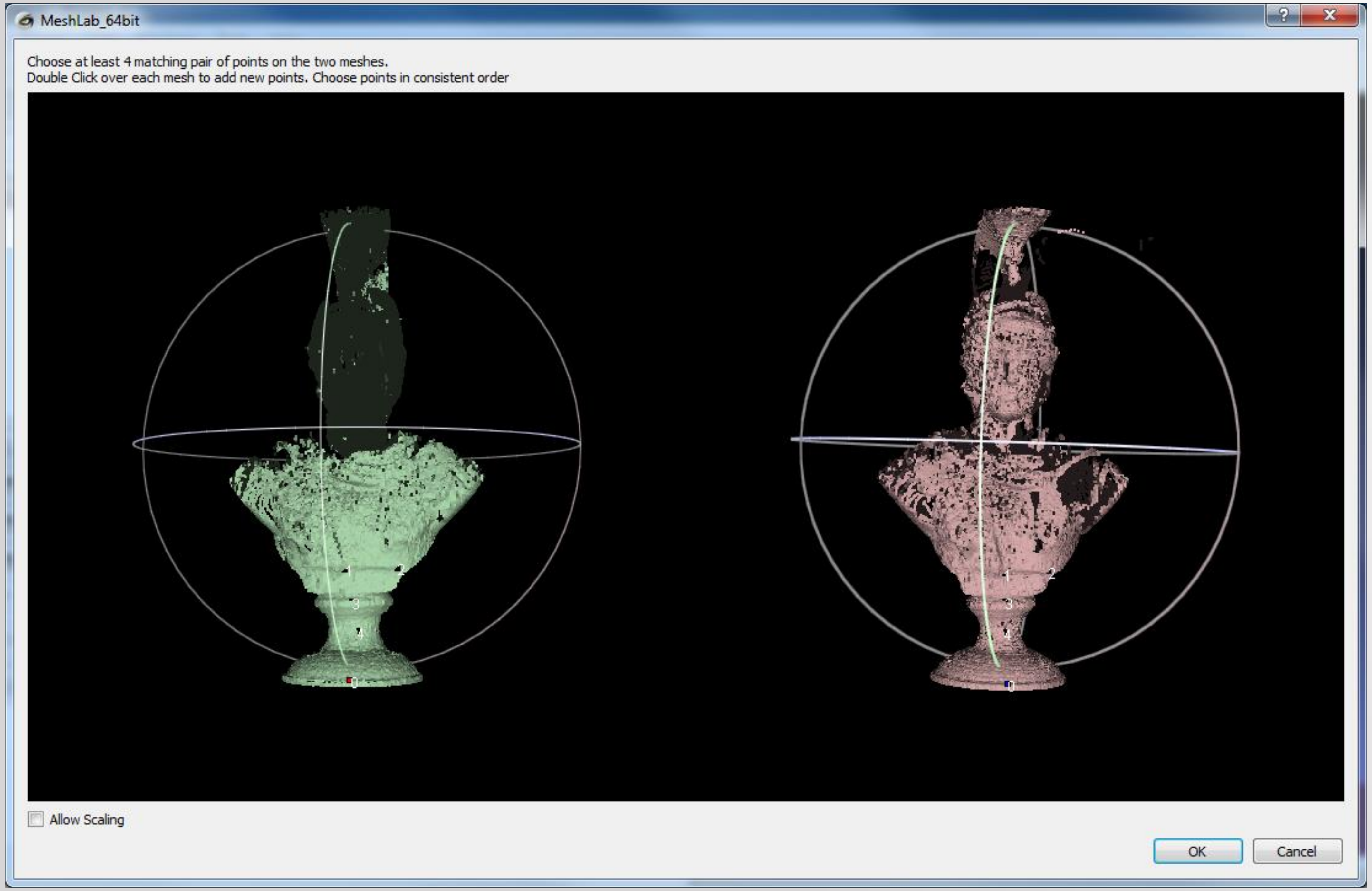


4. Joining clouds (optional)

In the *Tool panel*, we click on the first layer, and we glue it at the space (*Glue Here Mesh*)

Then, we select the second mesh, and click on *Point Based glueing*.

4. Joining clouds (optional)



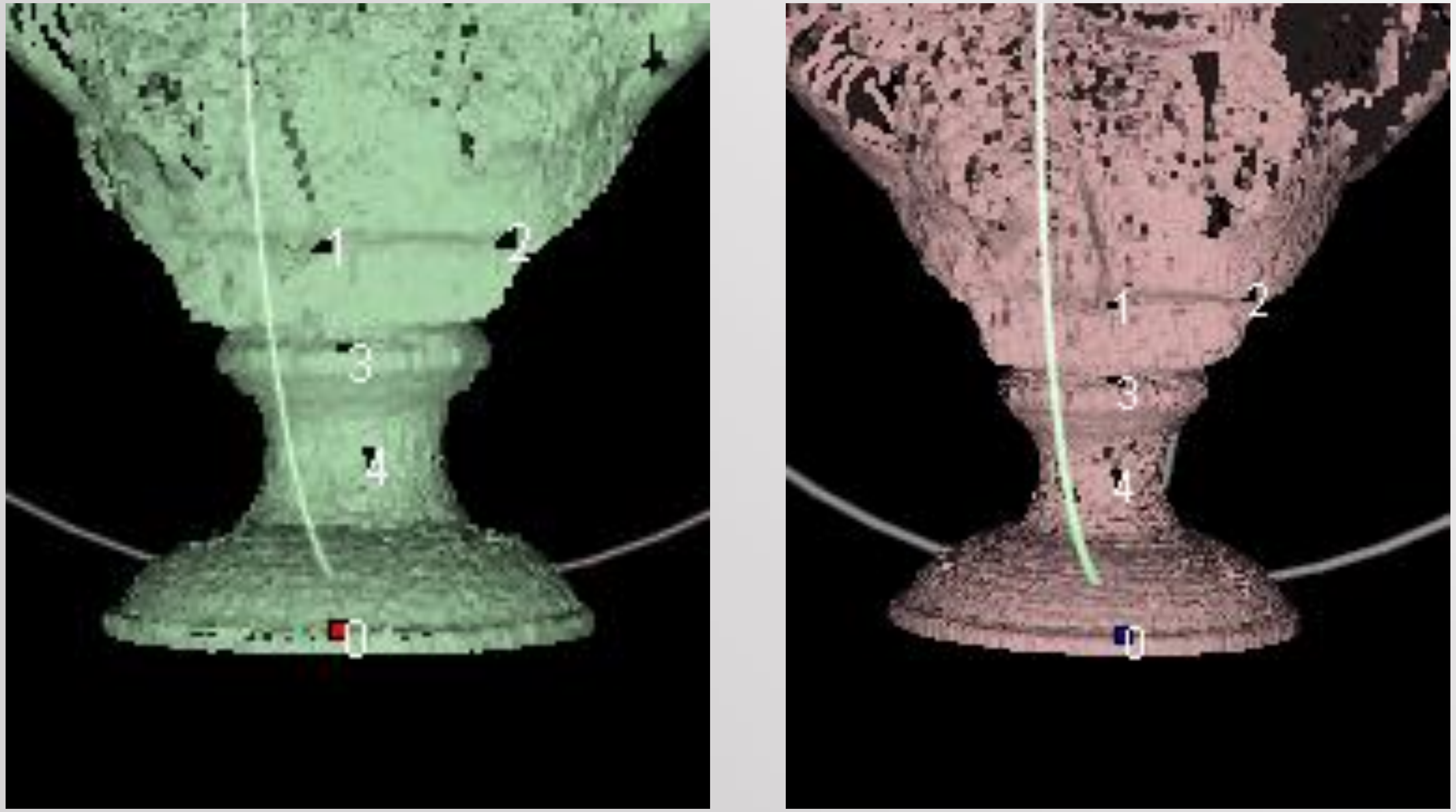
4. Joining clouds (optional)

In this window you have to select at least 3 points in common of both clouds.

Example: First a point cloud 1, and then the same point in the 2nd.

The choice does not have to be exact, can be approximated.

4. Joining clouds (optional)

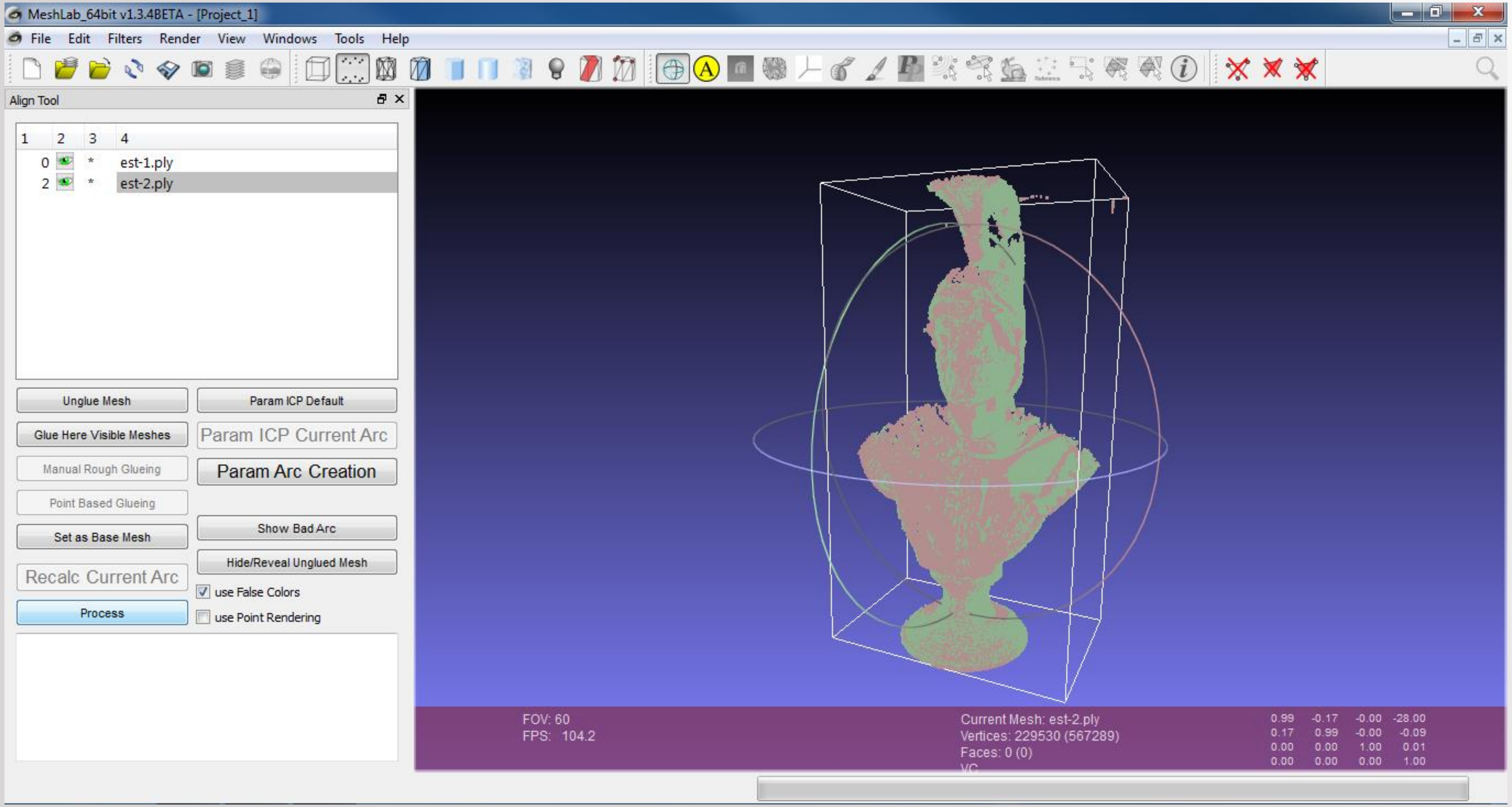


4. Joining clouds (optional)

The numbered points appear. If you select an invalid point you must cancel and repeat the process.

Once the points are selected, click on OK.

4. Joining clouds (optional)

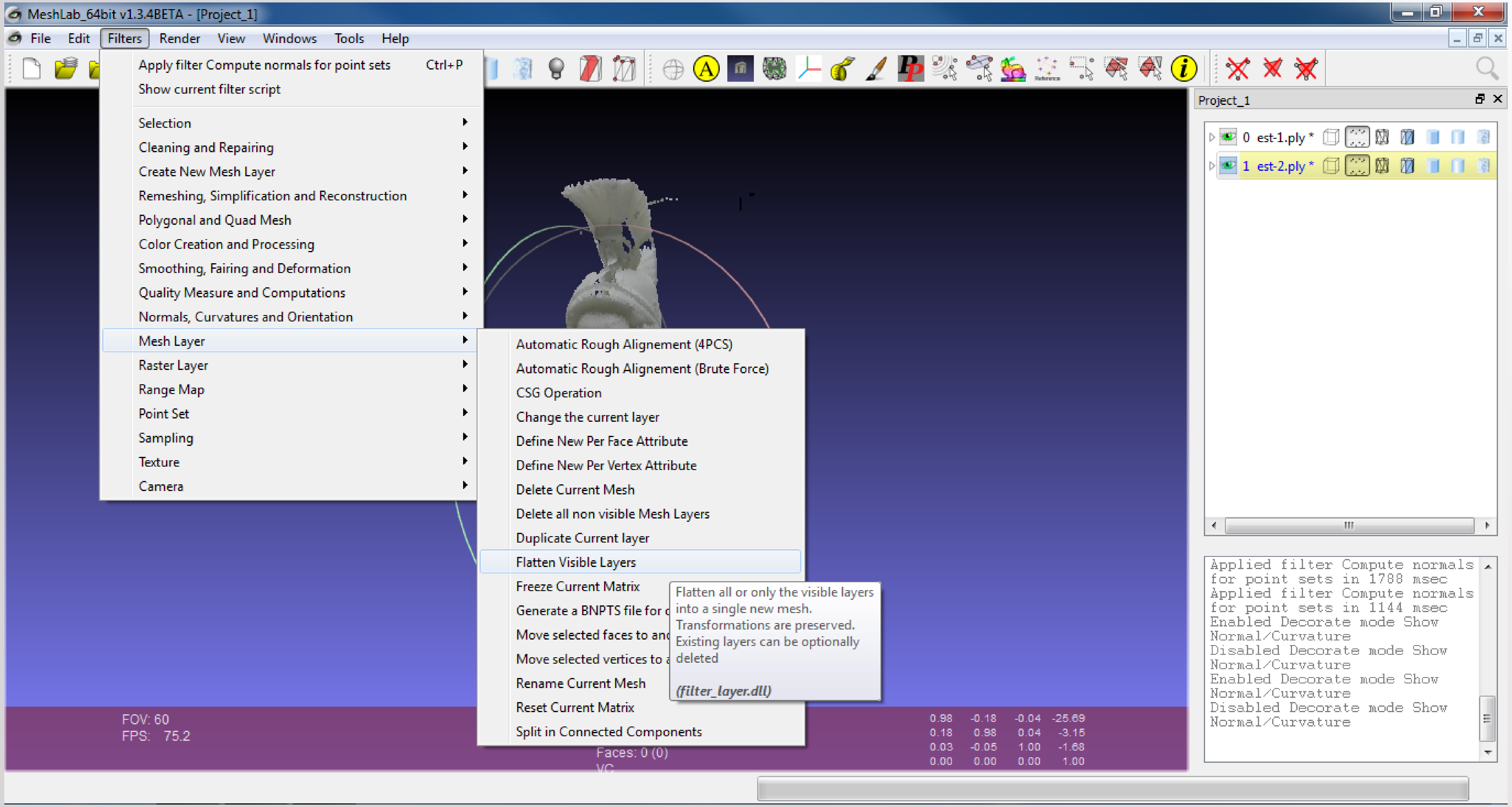


4. Joining clouds (optional)

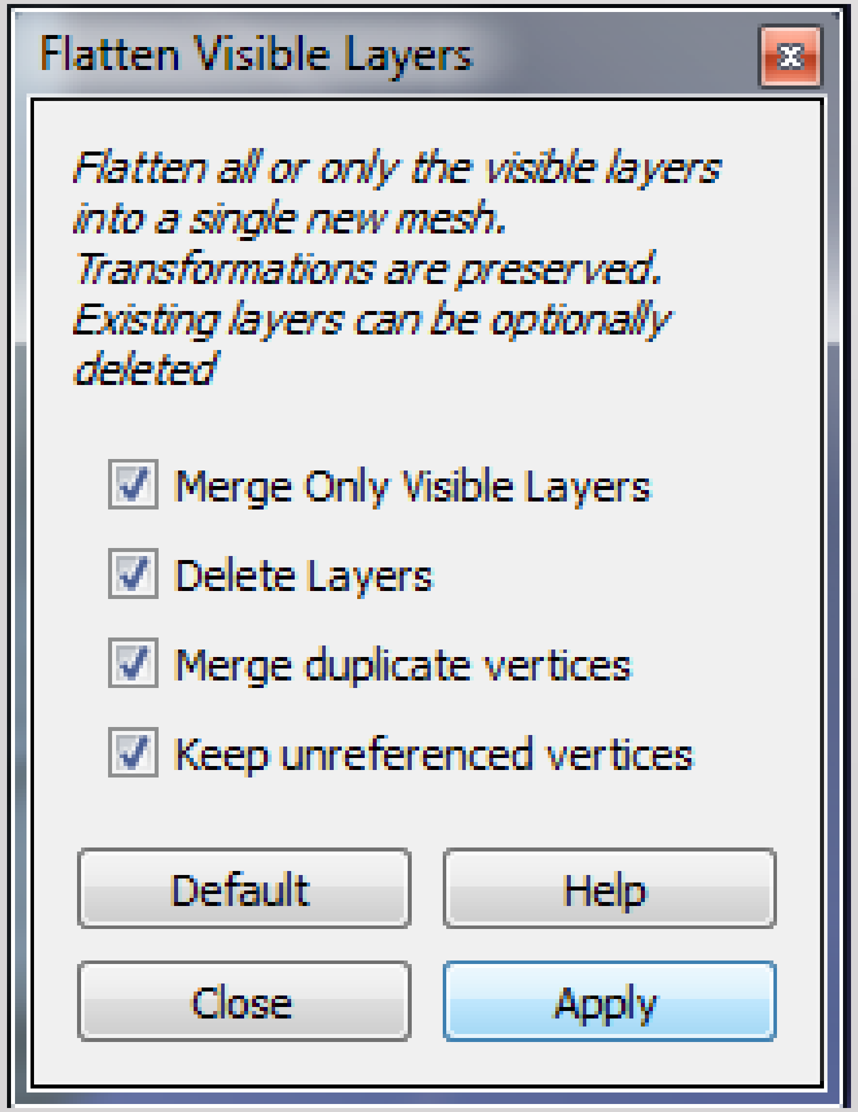
To join the aliened clouds:

Filters > Mesh Layer > Flatten Visible Layers

4. Joining clouds (optional)



4. Joining clouds (optional)



In this window we select Keep Unreferenced Vertices option

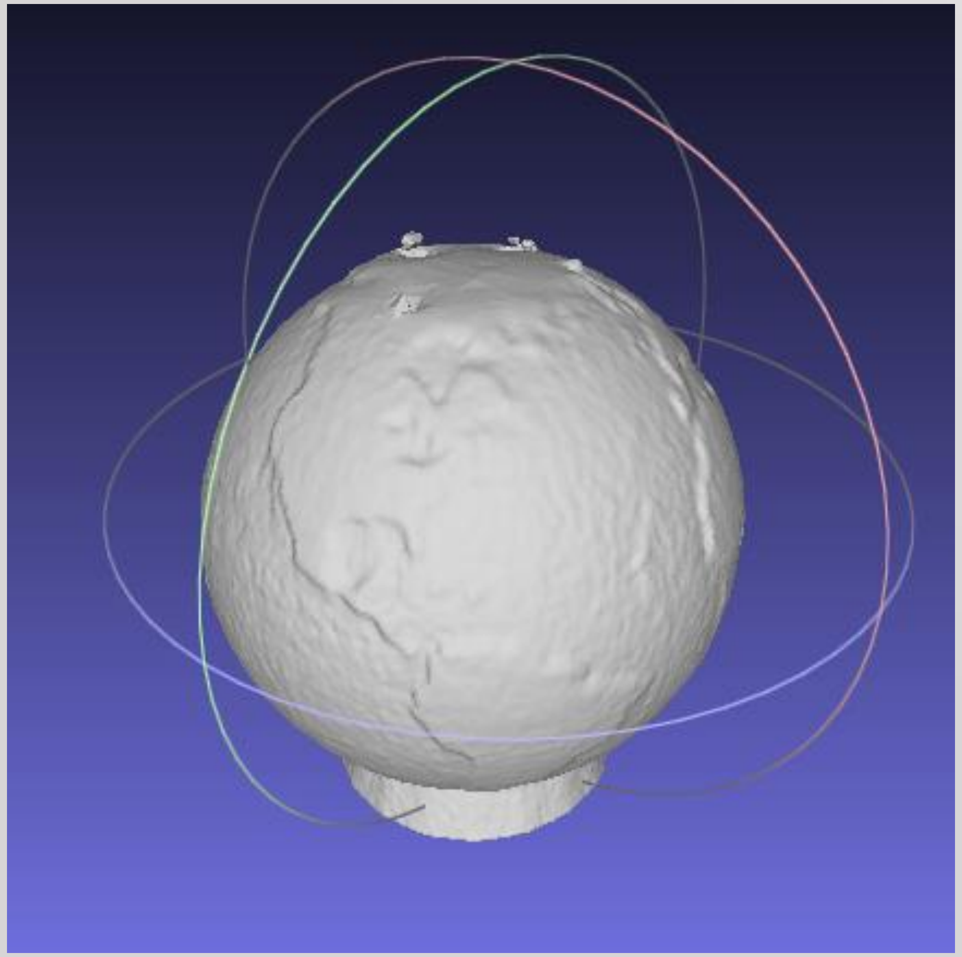
All other values will be left by default.

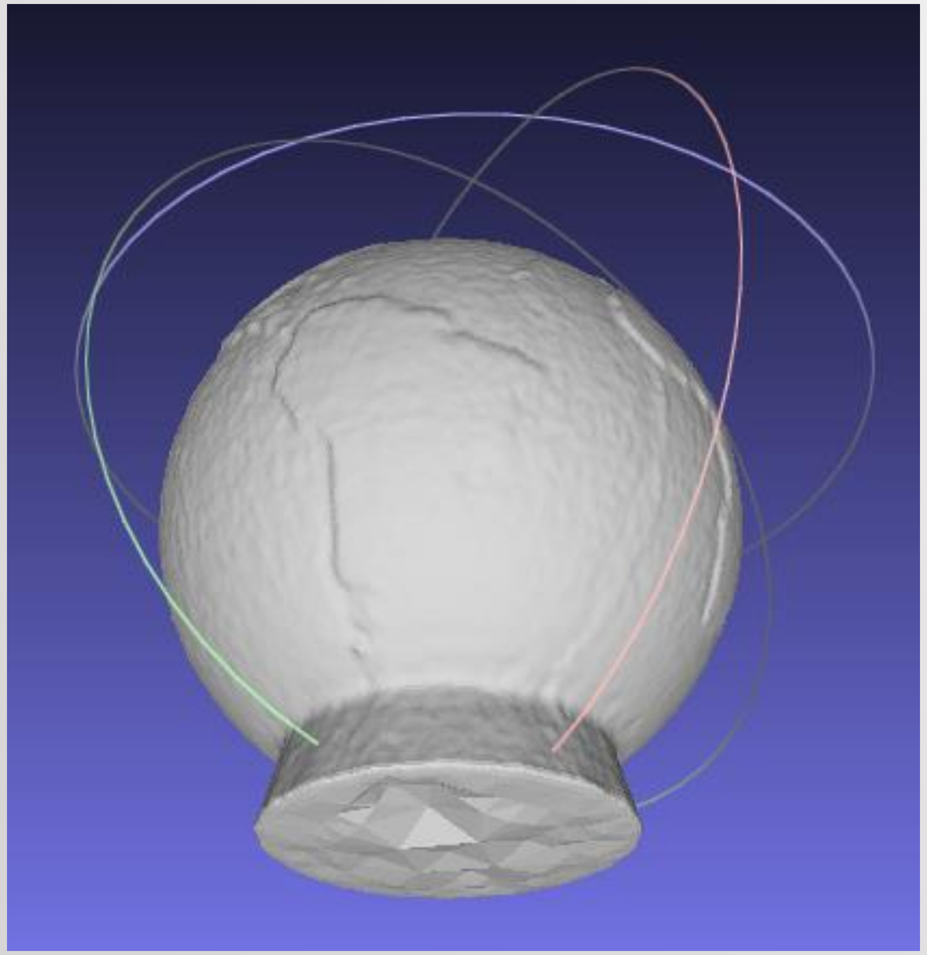
5. Smoothing the .STL (optional)

Although it is a process that can be performed with a different software, MeshLab gives the opportunity to smooth the STL reconstructed.

5. Smoothing the .STL (optional)

Our goal is to smooth the jagged faces

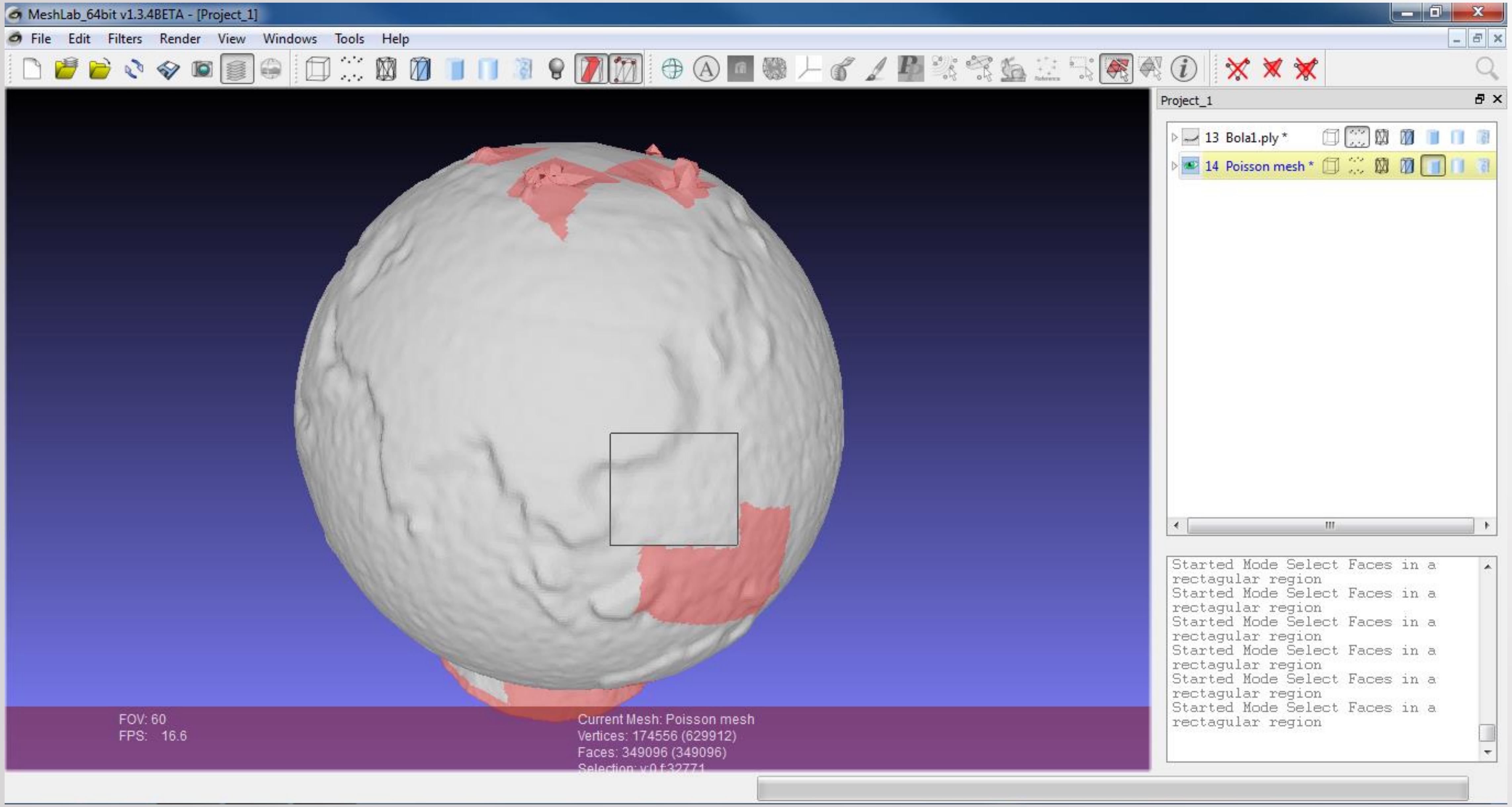




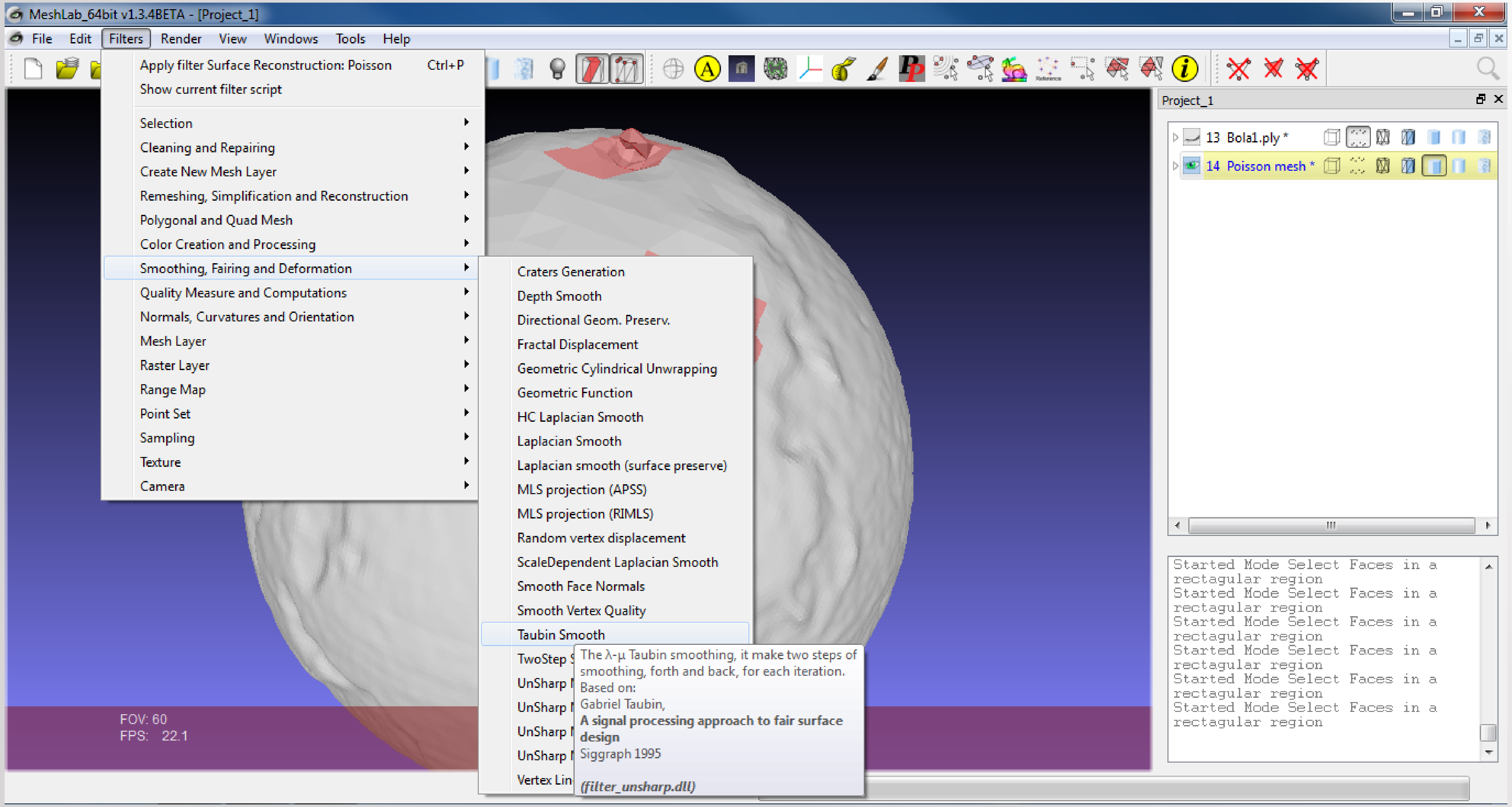
5. Smoothing the .STL (optional)

With the *Selection tool* faces, we select the faces that we choose to smooth, and then choose *Smooth Taubin*.

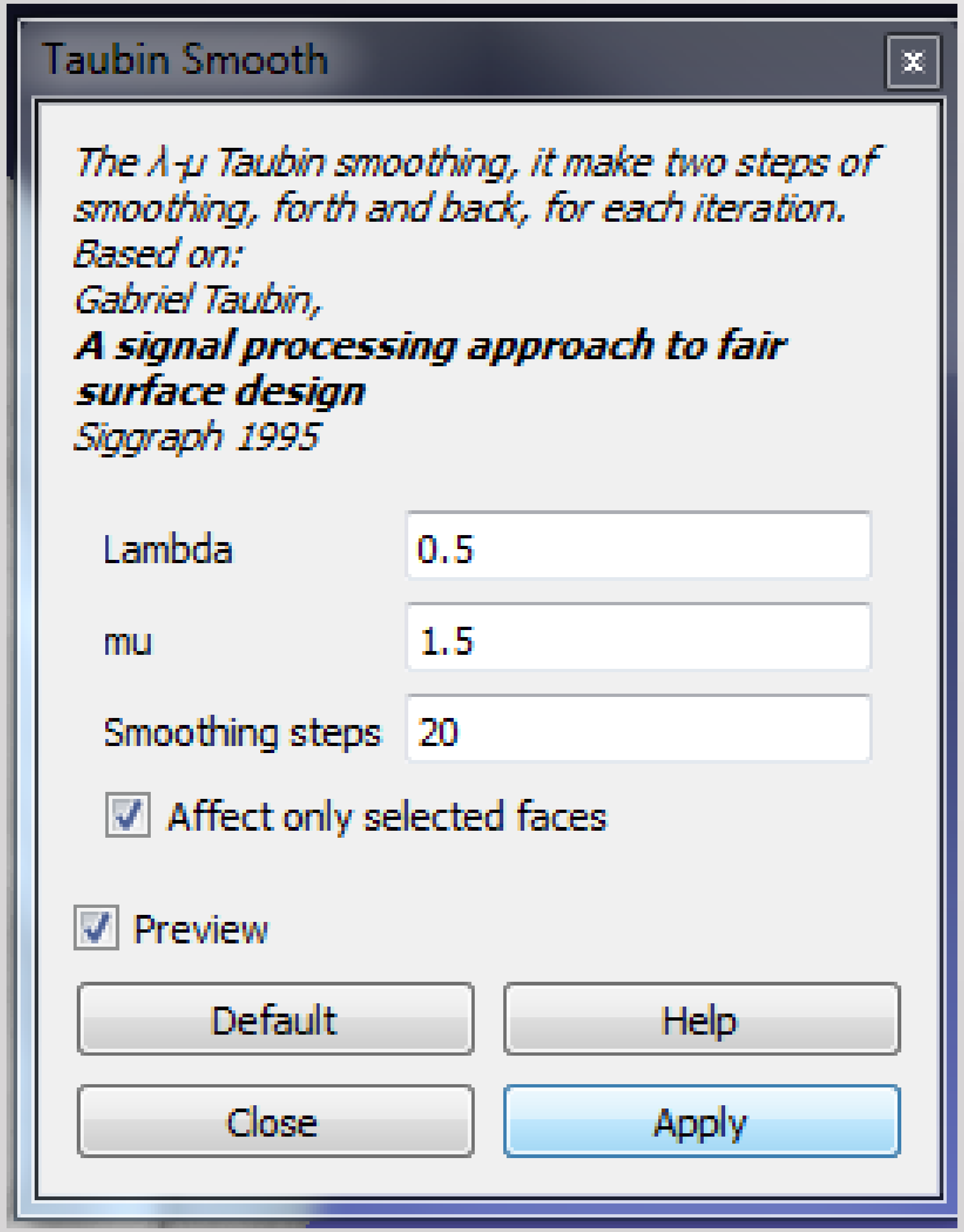
5. Smoothing the .STL (optional)



5. Smoothing the .STL (optional)



5. Smoothing the .STL (optional)

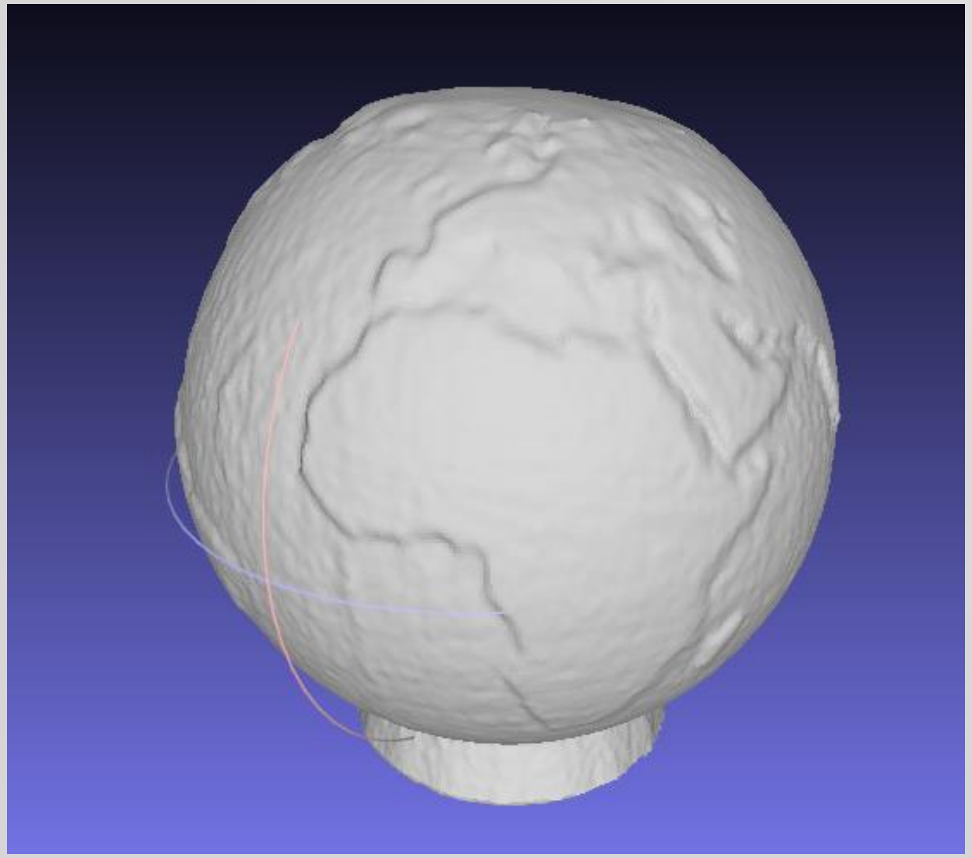


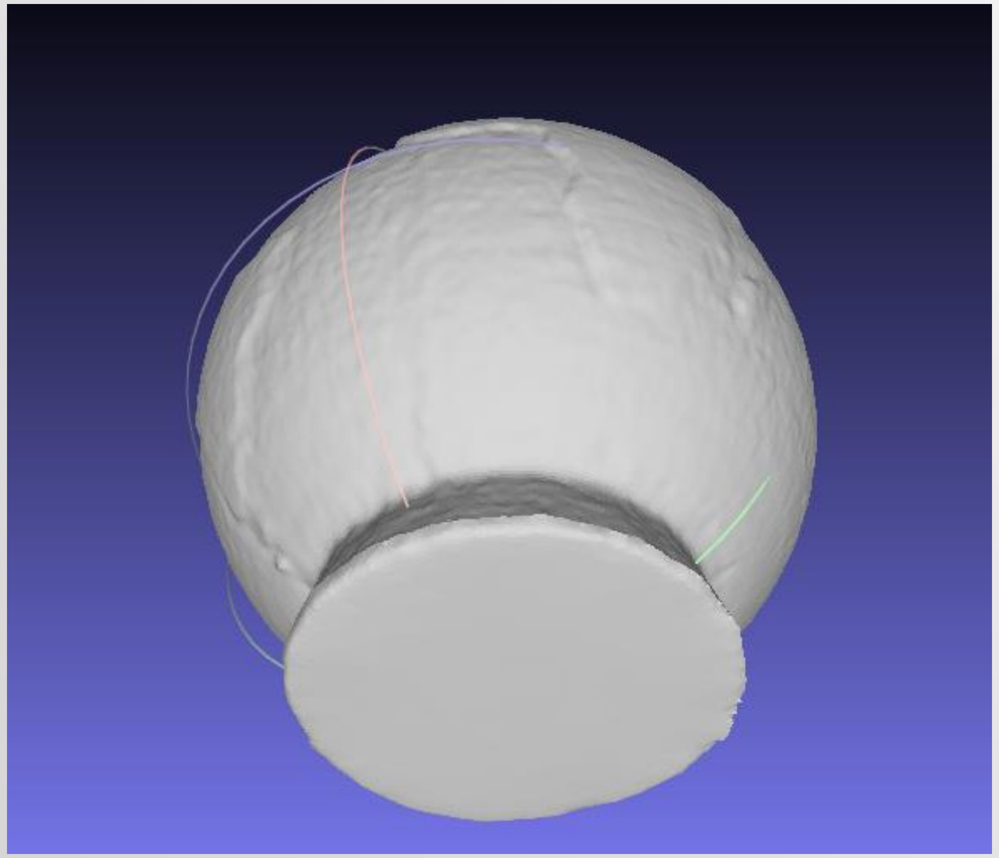
Lambda is by default.

About the rest of values, we recommend them as in the picture.

5. Smoothing the .STL (optional)

The result is the following:





bq

bq