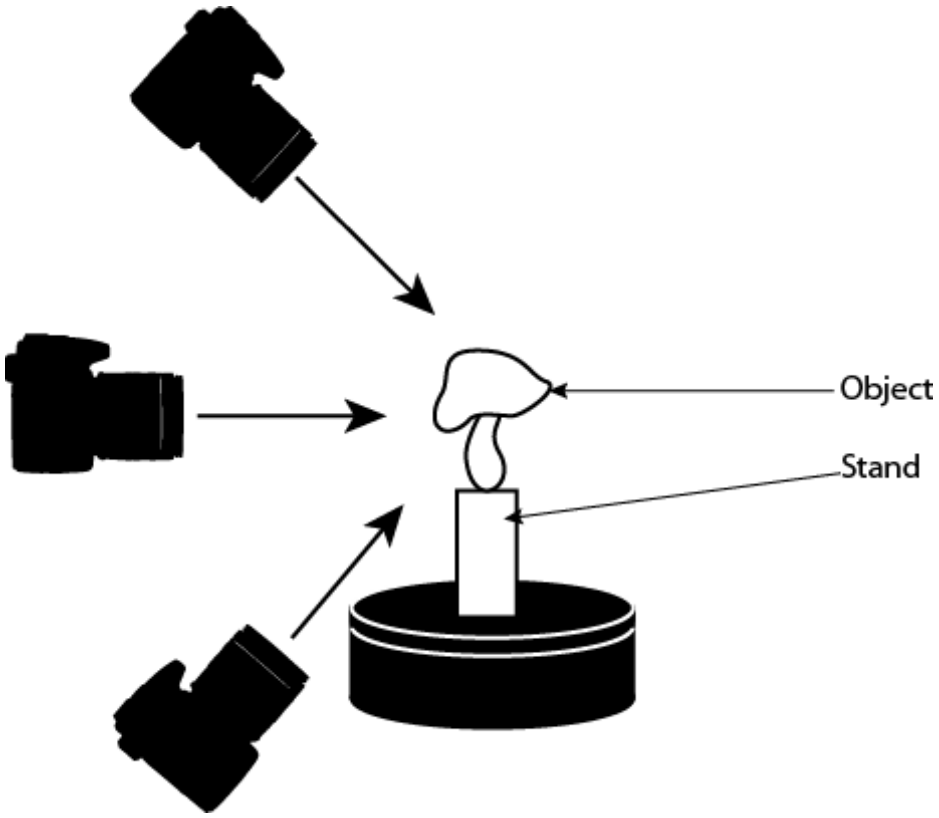
MS57 Training guide: 3D, Structure from Motion with Agisoft Metashape (RBINS & RMCA)

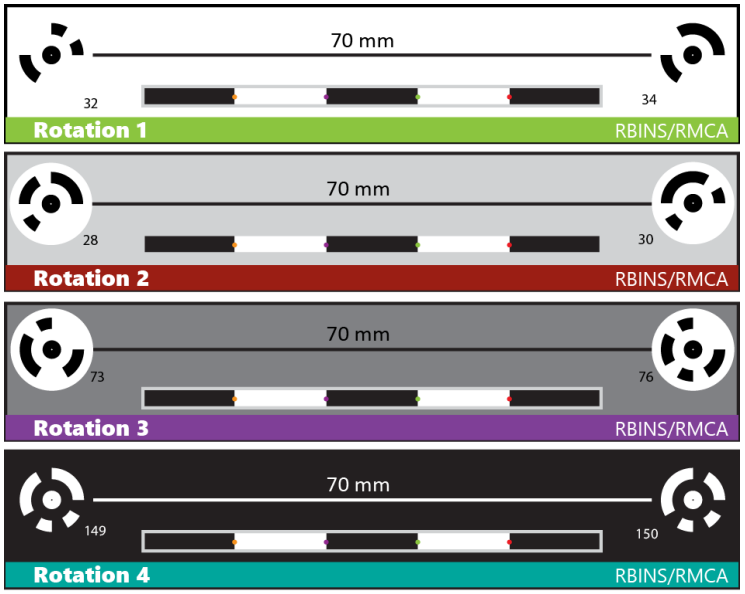
1. Acquisition

1.1. Prepare your setup:

- Place your object in the center of your turntable. If the object cannot be turned over, place it on a stand high enough so you can place your camera to capture images from below. You can use both an automated turntable or a manual turntable. If the object is too big to be placed on a turntable, the camera will have to be moved around the object.



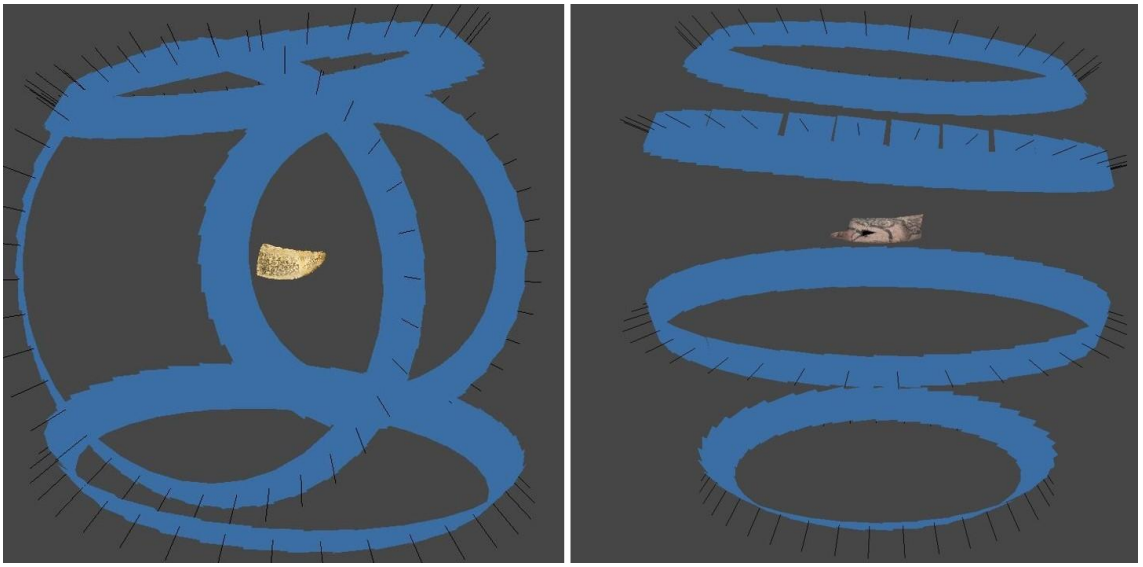
- Place a scale next to the object
- Try to have a uniform background and smooth and uniform lighting
- Set-up your camera (low iso, high f-stop, accurate exposure time, fixed focal length)
- Is best to use a tripod when possible
    - (with a tripod de-activate stabilization => stabilization creates noise)



Example of scales with photogrammetry targets

1.2. Capture

- Before starting the acquisition, plan your acquisition: define how many views and how many pictures you will need to take. Remember that you should have 80% overlap between the pictures.
- If you are using prolonged exposures, use a remote or a timer on the camera to avoid shake of the cameras.



Different capture strategies

1.2.1. Turntables

A. *Manual turntable*
   - You should prepare your turntable by indication graduation on it so you can know what steps is required to move the turntable between each view
   - You will need to manually move the turntable for each view

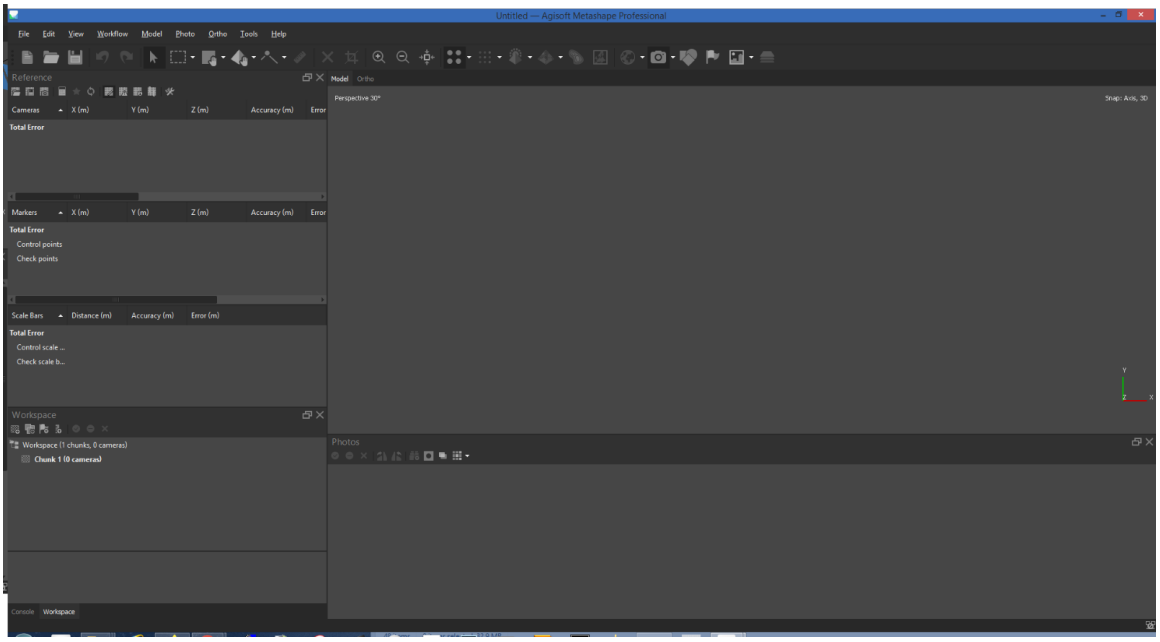
B. *Foldio360*
   - This is a commercial automated turntable. It is controlled through a smartphone or a touch pad via Bluetooth.
   - It will synchronize to the camera via the remote option of your camera.
   - The software allows you to define how many views you want per rotation.

C. *Agora3D*
   - In-house system, can be used with distinct size of turntable
   - The software allows you to choose the number of views per rotation and synchronize with the turntable and camera via cables.

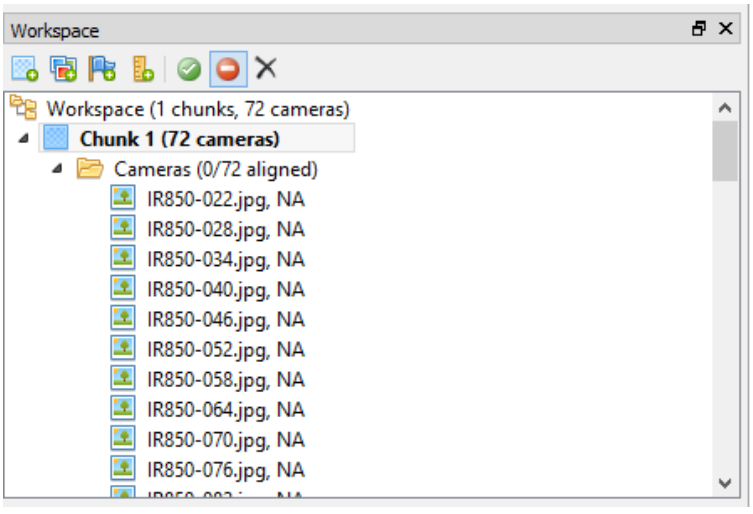
D. *No turntable => turning around the object*
   - For big objects or sites, instead of using a turntable, we will turn around the object.

2. Processing

a. Presentation of the interface



b. Once you have captured the picture, load them into your working folder.
c. Open a new Agisoft project. Your Agisoft project should be saved in the same folder as the pictures (you can use a sub-folder to separate the pictures by rotation).
d. Import the pictures in a chunk. You can just drag and drop the pictures in the chunk. If you are using several chunks, rename the chunks.



e. Basic workflow:
   - Mask pictures (File -> Import -> Import mask)
   - Align pictures (Workflow -> Align Photos)
   - Build dense cloud (Workflow -> Build dense cloud)
   - Build mesh from dense cloud (Workflow -> build mesh)
   - Build texture (Workflow -> build texture)
   - Detect targets and scale*[1] (Tools -> Markers -> Detect markers)
   - Export

- Creating a batch

2.1. Detailed workflows

2.1.1. 3 ways to masks your pictures

Mask by background

- Create a mask:
  - Either take a picture out of focus of your background without the object or create the mask in paint/gimp/photoshop
- “File” > ”Import” > “Import mask.” Choose Method “From background.” Choose tolerance according to the difference between the object and the background. It is possible to try different tolerances on the “current photo” to check it before applying it to “all cameras” or “entire workspace” (if your entire workspace has the same background).

Mask from model

- After performing the alignment, build a mesh from depth map (medium).
- “File” > ”Import” > “Import mask.” Choose Method “From model” => this method is useful when you don’t have a smooth background.

Manual masking

- Mask using the lasso or wand tools in Agisoft. This can be useful when you need a precise mask.

2.1.2. 2 ways to align pictures

In one chunk

- Place all your pictures in one chunk and mask your pictures, especially if you used a turntable. If you turned around the object instead, it is not mandatory to mask the pictures as the background can be helpful in the alignment (but it takes more time to calculate).

One chunk per rotation

- Place the pictures of each rotation in separate chunks.
- Align the pictures in the chunk
- Create a model from a sparse cloud if you have enough points, or from a depth map at medium resolution.
- Clean the resulting mesh (remove elements of background) and mask the pictures from the model.
- Two possibilities:
  - Merge all the chunk and re-align
  - If you have trouble aligning all the pictures, you can align the chunks together 2 by 2 and merge them gradually until you have a full model. To do that, select 2 chunks and align them together (“Workflow” > “Align Chunks”). In the “Align chunks” window select “Constrain features by
  - mask”. Once aligned, merge them (“Workflow” > “Merge chunks”). When chunks are aligned an “[R]” appears next to the name of the chunk on the workspace tab. Repeat the process with the merged chunk until you have merged all the chunks.

2.1.3. Optimizing/cleaning sparse cloud

Misalign cameras

- Manual selection -> right click -> filter photos by tie points -> Reset cameras alignment

Bundle adjustment (optional)

In order to obtain a more accurate model you can clean the sparse point cloud (we use an adaptation of the method described by H. Mallison, https://dinosaurpalaeo.wordpress.com/2015/10/11/photogrammetry-tutorial-11-how-to-handle-a-project-in-agisoft-photoscan/)

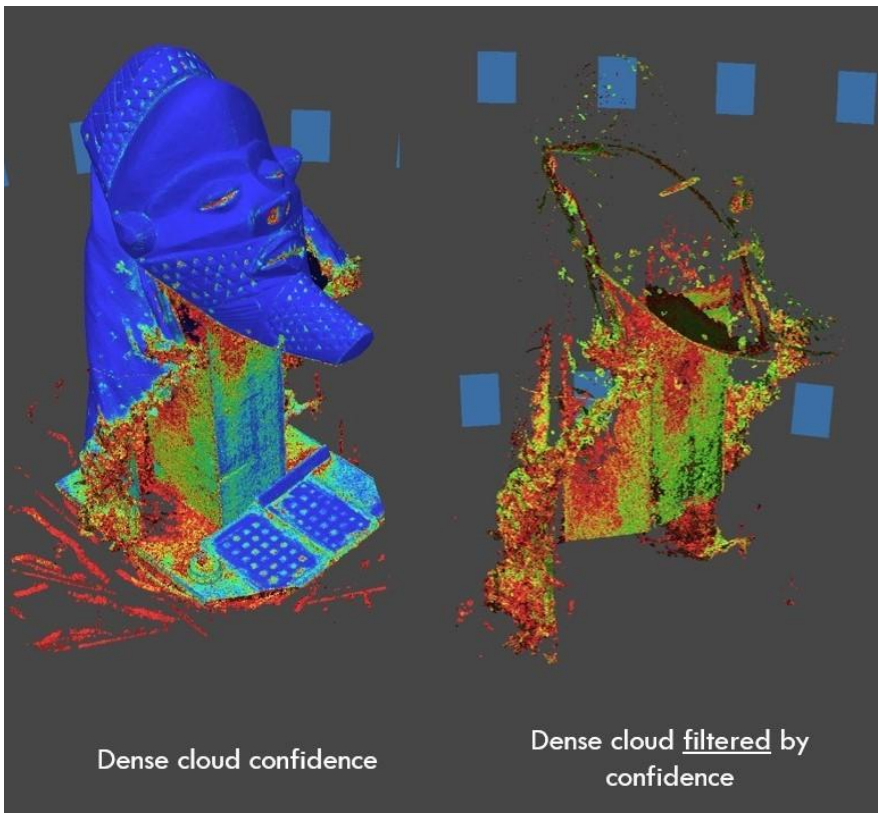
! Be aware that the cleaning process can reduce the amount of points a lot, sometimes too much, this is why we advise to duplicate the chunk at the beginning.

- Duplicate the chunk with your model
- Go to “Model” > “Gradual selection” > “Reconstruction uncertainty” and enter a number between 10 and 20.
- Go to “Tools”
- > “Optimize cameras” (default parameters only)
- Go to “Model” > “Gradual selection” > “Reprojection Error” and choose a value of approximately 0.5 or slightly lower.
- Go to “Model” > “Gradual selection” > “Projection Accuracy” and enter 10 (and go up or down eventually to match approximately 10% of the points).

2.1.4. Building a mesh

Before building a mesh, verify the size of the region.

- *Building a point cloud then a mesh*
  - The best result, but also the most time consuming, consists in calculating a dense cloud, then clean it and build a mesh from the dense cloud. (Workflow -> Build dense cloud; Workflow -> Build mesh -> from dense cloud)
  - Cleaning the dense cloud:
    - By manual selection
    - By color
    - By confidence



- Cleaning the mesh
    - By manual selection
    - Automatic selection (Model-> Gradual selection -> By connected components size/By polygon size)

Building a mesh from depth map

- If you are looking for a nice model for visualization purposes and do not need as much precision, you can calculate a model from a depth map as it is faster.

Increase quality => use strict volumetric masking

- If you have an element with lots of small tiny details like hairs or spines, you can obtain a better model by using the option “strict volumetric masking” when you calculate the mesh, but be sure that your masks are accurate and precise (often you will have to do manual masking for that).

On the left: no strict volumetric masking. On the right: mesh with volumetric masking.

2.1.5. Building texture

- Workflow -> build texture -> diffuse map & occlusion map

! Texture size should always be in those values 1024-2048-4096-8192. The higher the better, but not too high either otherwise the computer will not handle it.

2.1.6. Creating a batch process

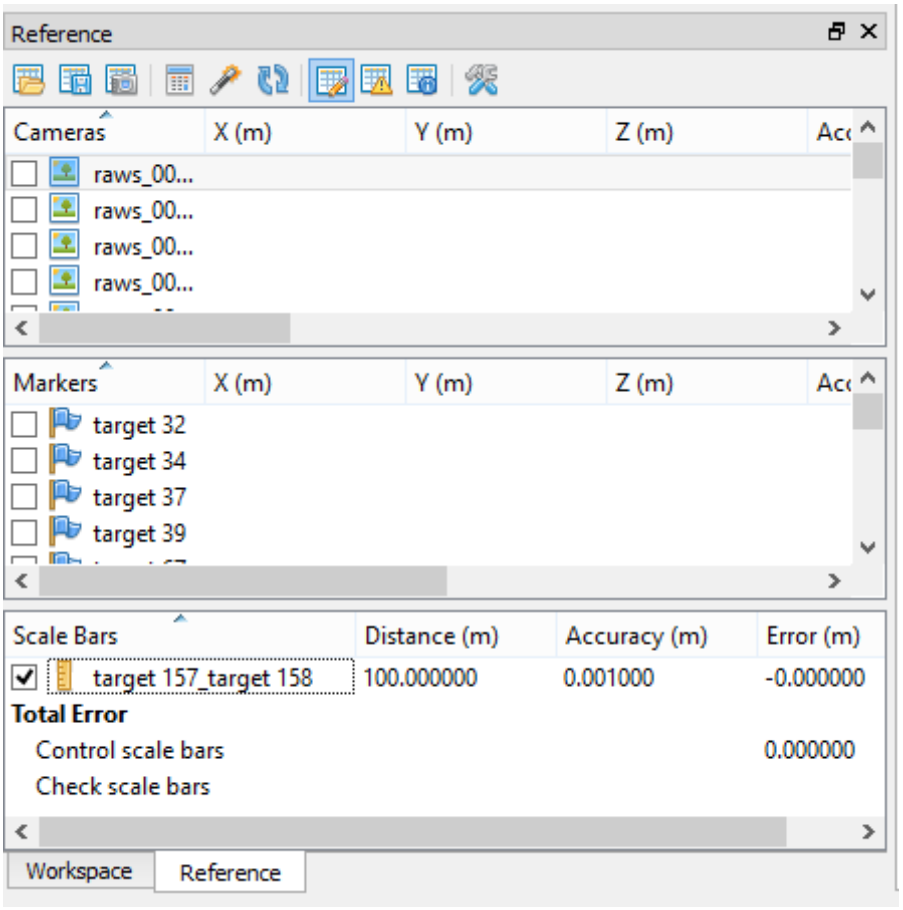
- Most of the steps detailed above can be included in a batch process. To do that, open the batch process dialogue (“Workflow” > “Batch process” > “Add…”) and add the steps you want.
- You can also ask the batch to load new projects once he finished the previous one.
- You can save the batch file to load it for each photogrammetry process.

3. Post-processing

3.1. Scaling the model

By photogrammetric targets

- Tools -> Markers -> Detect markers
- Reference tab -> select 2 markers -> right click -> Create scale bar
- In scale bar input the distance between your 2 targets (unit is the meter)
- Update



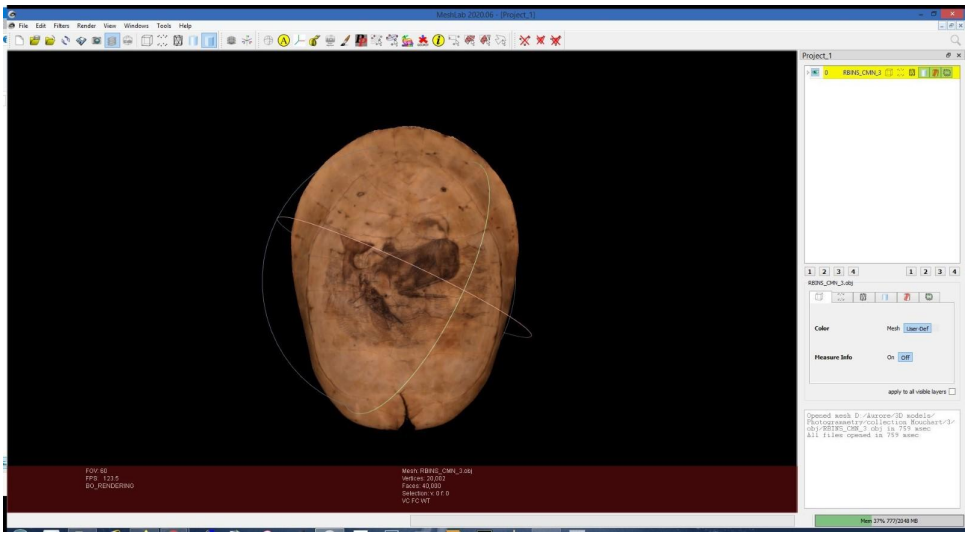
Reference tab for scaling the model

By user define markers

- Right click on the picture where you want to create the markers
- Place the markers on 3 or 4 images
- Reference tab -> select 2 markers -> right click -> Create scale bar
- In scale bar input the distance between your 2 targets (unit is the meter)
- Update

Scaling in Meshlab (https://www.meshlab.net/)

- Select 2 reference points on your object, and measure the distance between them
- Select the point to point tool in Meshlab to measure the distance on the model
- Calculate the scale ratio:
    - Real Measure ÷ 3D model measure = Scaling ratio value
- Go to Filters -> Normals, curvature and Orientation -> Transform: Scale, normalize:
    - Insert the scaling ratio and check “uniform scaling” and “Freeze matrix”
- Ctrl + H and check the measurement are now accurate

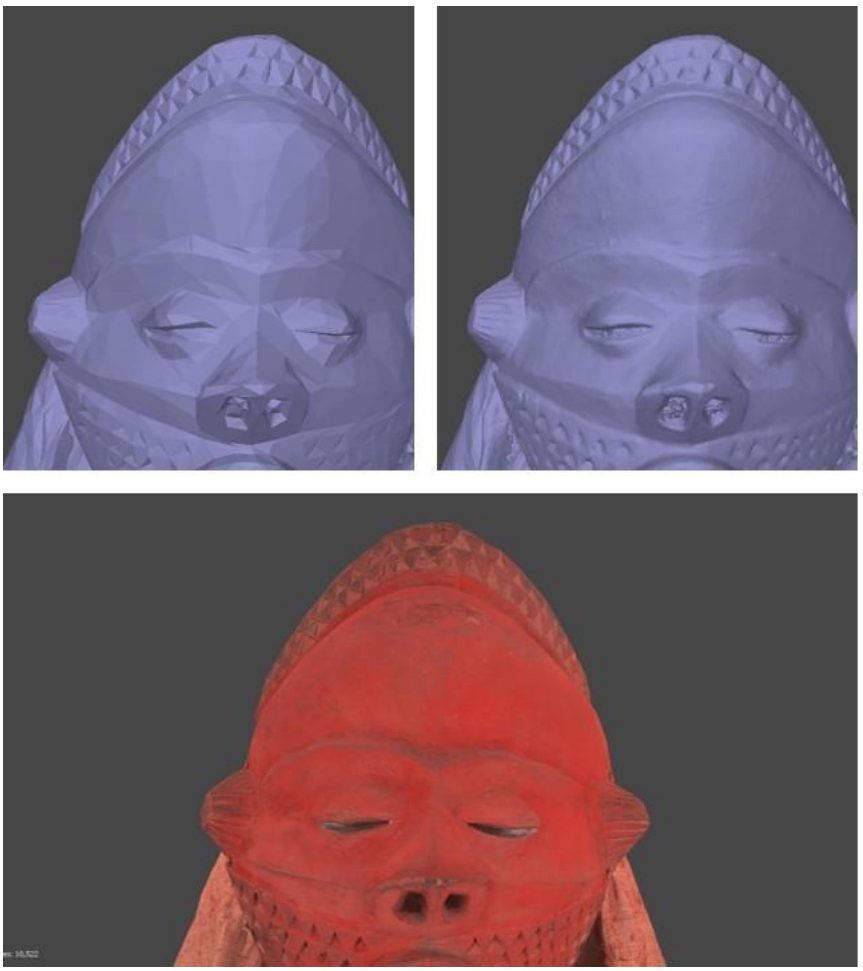


Meshlab interface

3.2. Optimizing model

Decimation and creation of a normal map

- To have a low poly mesh with good visualization we will first decimate the high-resolution mesh to the amount of polygon wanted (Tools -> Mesh -> Decimate mesh)
- A message will pop-up on screen “Replace default model?” => NO
- Now the chunk contains 2 models, one with low-resolution and one with high-resolution.
- Go to “Workflow” -> “Build texture”, select “normal map” as texture type and select the high-resolution model as source data
- Calculate the diffuse map and occlusion texture again



On the upper left: decimated model.
On the upper right side: high resolution model.
Lower image: Decimated model with normal map and diffuse map.

4. Tips

- Avoid running other tasks on your computer while aligning the pictures and never align 2 models at the same time in 2 Agisoft windows.

- If you have reflective objects, you can use cross polarization: Hallot, P., & Gil, M. (2019). Methodology for 3d acquisition of highly reflective goldsmithing artefacts. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLII-2/W17*, 129–134. https://doi.org/10.5194/isprs-archives-xlii-2-w17-129-2019

- Close holes in external software like GOM Inspect.

5. Credits

- Author: Aurore Mathys
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- Version: 2.0
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