Photogrammetry Guide to Creating Digital 3D Models

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Guide Version 1.0

Part I - Photography

Create studio setup with black cloth backdrop - try to black out as much of the surrounding area that could possibly show in the photograph. This includes the turntable itself (this was covered with a black piece of construction paper), which should be placed centered in the area leaving room for the lights on either sides.

1. Set up lights - be prepared to move the lights for each individual specimen avoiding shadows as much as possible. Two standing desk lamps are used on either side, and a clamp desk lamp is used to diminish the shadow under the specimen/lighting crevices.
2. Plug Micro-USB into computer and camera and open 'Remote Shooting' on the EOS Utility program, click 'Live View shoot', align the specimen so that the specimen fills the view as much as possible. Place specimen in the center of the turntable and then focus the camera on the specimen.

*Camera was set to AV, Aperture - F32, ISO - AUTO, Image Quality - L 6000x4000.

3. Next select 'Depth-of-field preview' - this allows more of the specimen to be in focus in the photo. Be sure to check that the specimen stays in view as it is rotated on the turntable - adjust the lights as needed, also there is an exposure control on the Shooting menu
4. Take a photo of the specimen every ~10 degrees of rotation.
5. Once finished with the first round of photos, rotate the specimen and repeat the process - do this for three to four different angle or until all angles/surfaces of the specimen have been photographed in more than one angle.

Tips
- Use box of sand for balance, whether that be sticking the specimen into the sand or leaning it against the box. In some cases, the box of sand can be covered with some black cloth to minimize the need for masking. If the specimen has to be stuck into the sand for better balance, be sure to photograph the parts of the specimen that were in the

sand in another angle. It is best to start with the entirety of the specimen showing in the first set of photos, and then in later photos go into specific parts.
- For flat slab specimens, the first set of photos should be where it standing straight up using cloth to balance it or on its own if possible and then place it flat for the second set of photos. If it is leaned against the box of sand make sure to flip the specimen to photograph all of the back as well.
- If there is wobbly specimen, some sand can be poured onto the turntable to diminish the movement.
- The number of total photos will depend on each specimen individually. Typically they should range between 108 - 216, which is between 3 - 6 different angles.
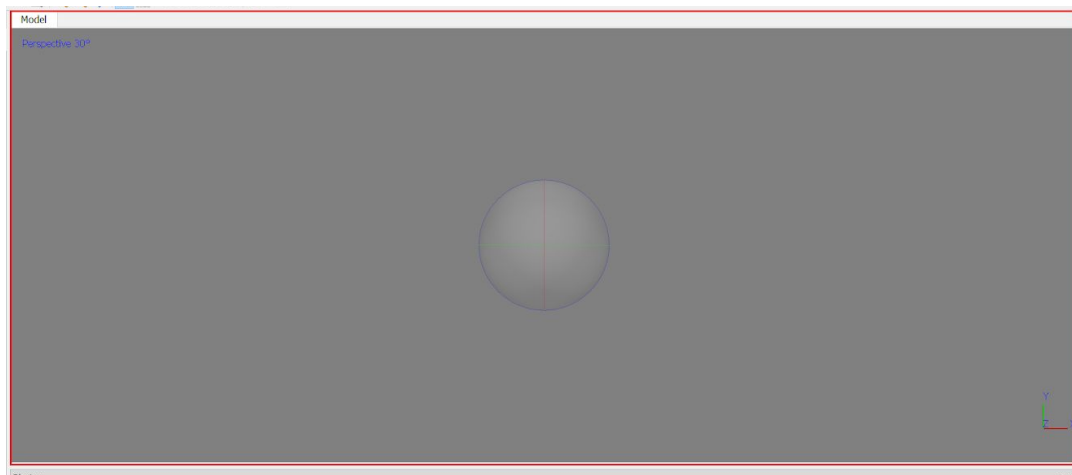
Part II - Model Development in Agisoft

Understanding Agisoft Standard

Basic overview of a new Agisoft Standard file
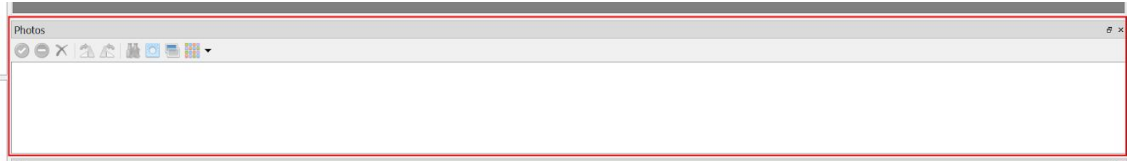   a. Model Perspective
        - This is where the model can be viewed and edited during the photogrammetry process. The sphere in the center can be used to center the model - this also shows you that you are in navigation mode. The red, green, and blue lines are the x, y, and z axises of the model and can be used to rotate the model in a single axis direction.
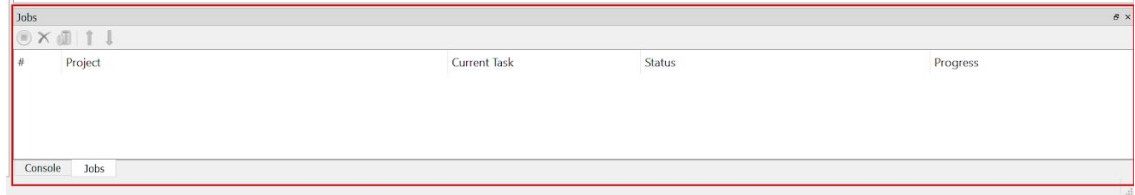

    b. Photos
        - This is where the images of the specimen can be accessed, masks can be viewed, cameras aligned can be denoted by the green check marks in the upper right of the image.
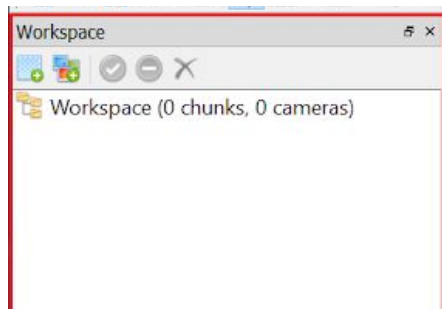
c. Jobs
- This is where the progress of each task for the model will show.

d. Workspace

- This is where the chunk(s) will be managed - chunks are groups of photos that will be used for the model. If you have multiple chunks, you will have to double click on another to change. Cameras are the individual photos within the chunks. Once the photos have been aligned there will be a third count of 'points', which shows how many points have been matched between all of the photos.
    - Add Chunk - This creates a new chunk where the photos of the specimen will be added
    - Add Photos - This will images to be selected for and added to the chunk.
    - Enable Items - This allows for selected items to be used for the alignment process.
    - Disable Items - This allows for selected items to not be used for the alignment process.
    - Remove Items - Deletes selected items

e. Toolbar

New - Opens a new file
Open - Opens a saved file
Save - Saves file

Undo - Undoes last action
Redo - Redoes undid action

Navigation - This allows for control over position and angle of model.
Rectangle/Circle/Free-form Selection - This allows for the selection of specific points or mesh.
Move Region - This allows for the location of the region where the model is created to be moved.
Move Object - This allows for the location of the model in the region to be moved.
Delete Selection - Deletes selected points or mesh
Crop Selection - Deletes not selected points or mesh

Point Cloud - View of basic point cloud
Dense Cloud - View of dense point cloud
Shaded - View of basic vertex colored mesh
Solid - View of solid colored mesh
Wireframe - View of wireframe Mesh
Textured - View of final textured mesh

Show Cameras - View of camera location and angle placement of photo alignment
Show Aligned Chunks - If there are multiple chunks, after you align them, using this you can view them in the same model perspective.
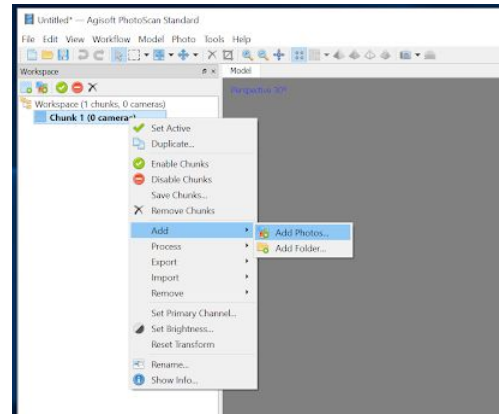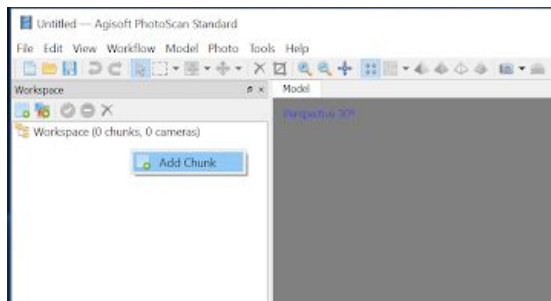
f. Mouse controls and Keyboard shortcuts
   - Toggling between navigation and any selection tool can be done by pressing the spacebar.
   - The scroll wheel can be used to zoom in and out, but also can be clicked to move the model. This will help center the model in the Model Perspective
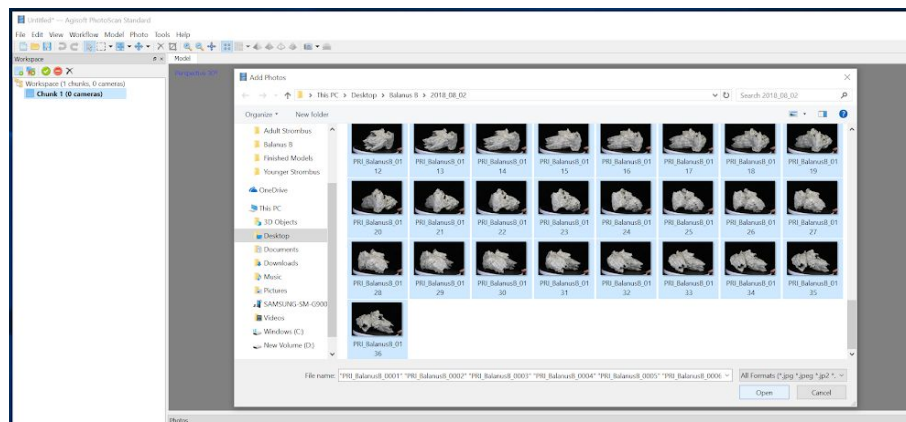
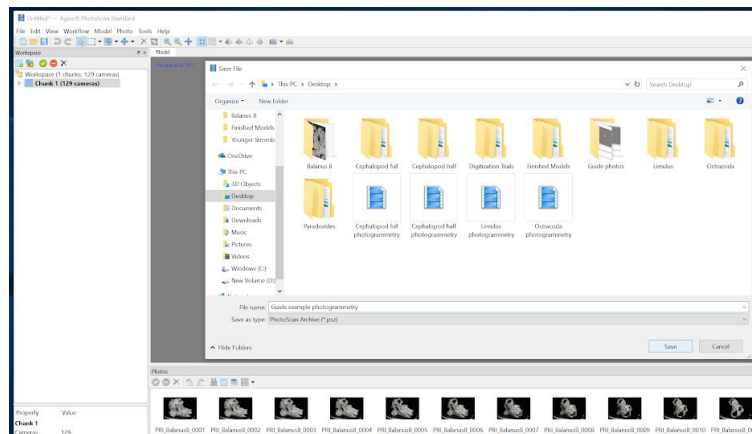# Development of the Model

Uploading Photos
1. Open new Agisoft file
2. In 'Workspace' right click and select in the drop bar - 'Add chunk' - this will be called 'Chunk 1'.
3. Right click on 'Chunk 1' and in the drop bar hover over 'Add' then select 'Add Photos…' - these will be called cameras.

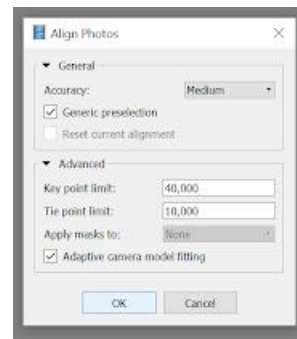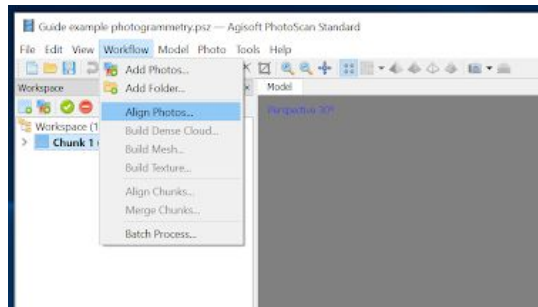4. Find and select all desired photos of specimen and then click 'Open'.

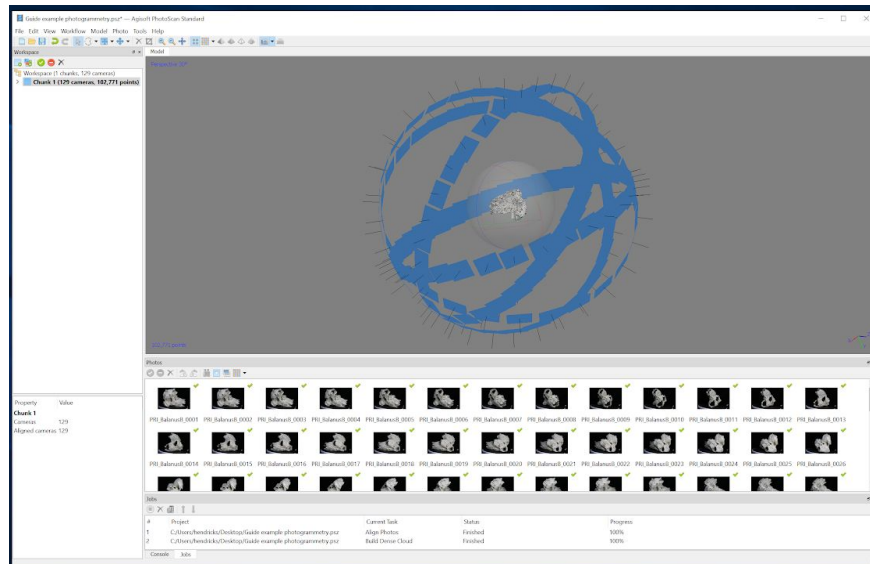5. Now save the document under '*Specimen name* photogrammetry'

Aligning Photos

1. In the toolbar, click 'Workflow' - 'Align Photos…'.
    - This will bring up an options window where photos can be chosen to be aligned at multiple different accuracies and point limits can be adjusted, but for this procedure we will only be changing the accuracies. (Key point count: 40,000; Tie point limit 10,000)
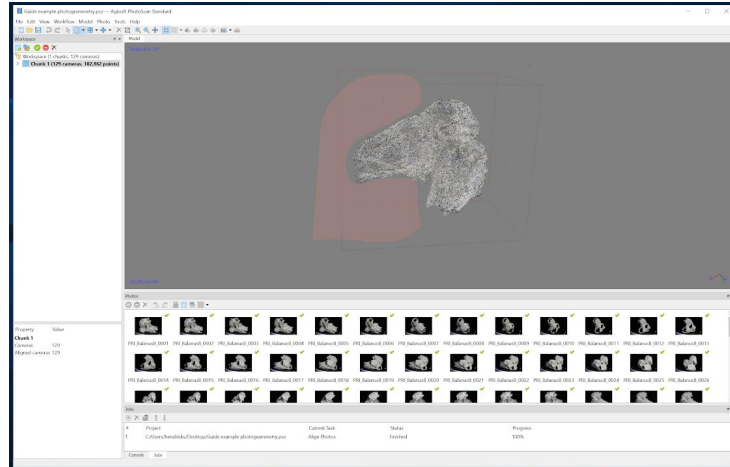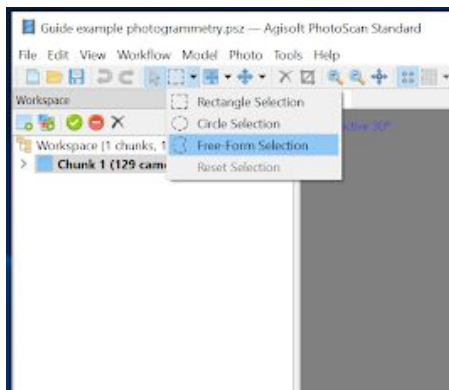2. Select Medium accuracy for alignment and then click 'OK'.

- This may take some time to finish, so feel free to photograph or process other specimens during this time.
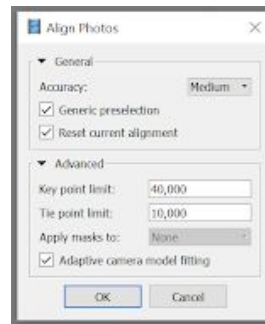- Once it is finished be sure to SAVE!

3. Analyze camera angles/locations by selecting the camera icon in the toolbar. Select the cursor icon in the toolbar to be able to rotate the model with your mouse.

- If the model and camera angles look correct then select the 'Free-form' selection tool in the toolbar and remove any excess distal points that do not belong to the model. This is done by clicking and dragging the cursor to select an area of points. The highlighted area and points selected will turn red, then use the 'delete' on the keyboard.

- If the camera angles/basic models does not seem correct, e.g. the model has no distinct shape or there are blue photo locations stacked on top of others, run the photo alignment again at either High, Medium, or Low accuracies. The program will run and match different points together each time the photo alignment is done - make sure to select 'reset current alignment' in Photo alignment options window.
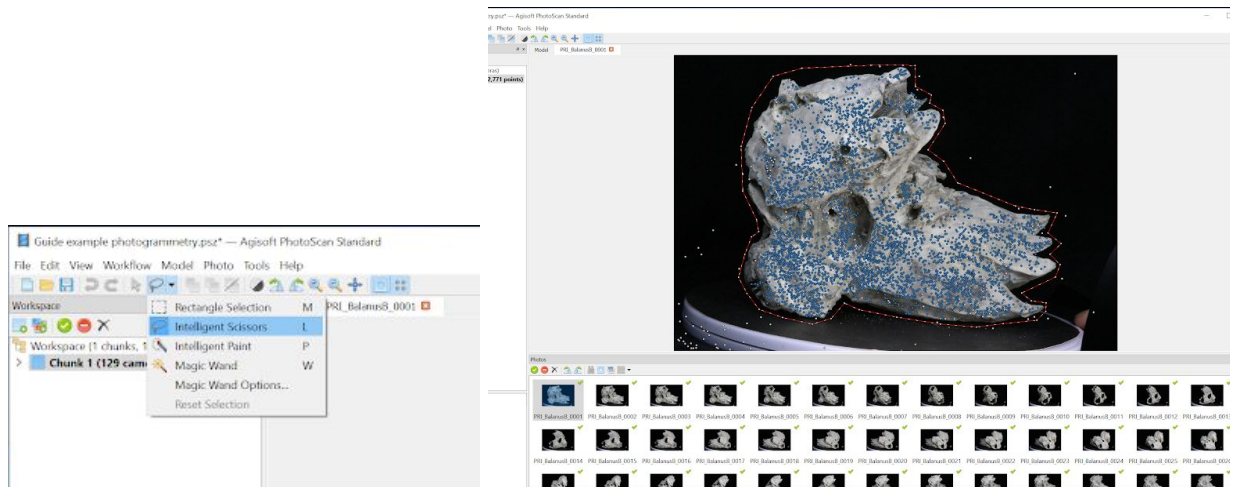

- If running the photo alignment multiple times does not work and the points will not align on their own, then each image will have to be masked individually to narrow the point selection for the alignment.
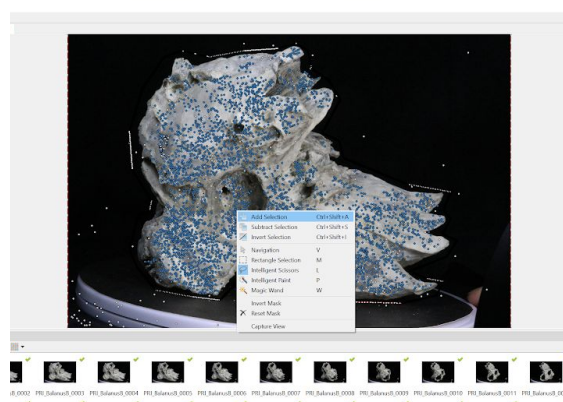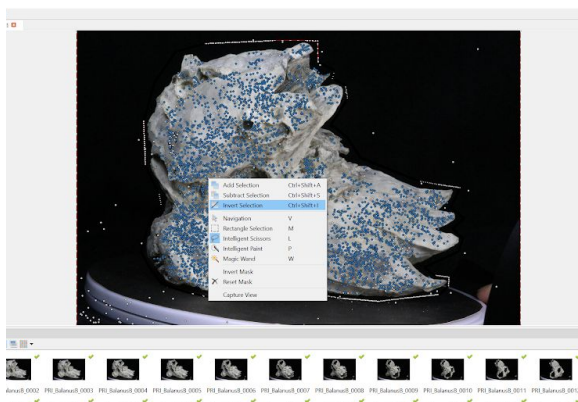
Masking an Image

Skip these steps and continue to 'Building Dense Cloud' section, if camera locations and basic point cloud model are aligned correctly.

1. In the 'Photos' section, double click the first image labeled *PRI_*Specimen name*_0001*. In the toolbar, select the 'Intelligent scissors' (the lasso icon in the selection tools drop box) or press the 'L' letter key.
   - The 'Intelligent scissor' tool creates a continuous line to select irregular shaped areas.
   - For this step, the goal is to mask the majority of the background. Unlike the previous 'Free-form Selection' tool, this selection tool works by placing individual points around the specimen by clicking and not dragging.
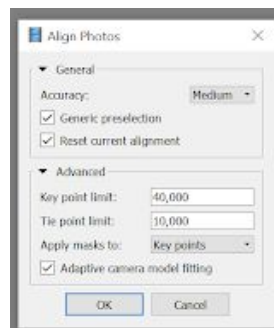
2. Make sure to follow the edge as closely as possible, but make sure none of the actual specimen is masked. To end the 'Intelligent Selection' line, place a finishing point where the first initial point was placed.

4. Since we want to mask the background and not the specimen itself, we will need to invert out selection which can be done by right clicking and selecting 'Invert Selection'. Then right clicking again, select 'Add Selection'.
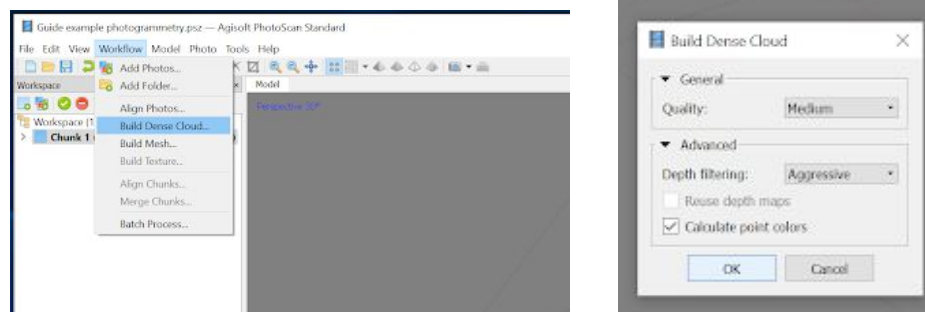

5. Repeat this process until each image is masked. Remember to save continually throughout the masking process.
6. Once all images are masked, return to the photo alignment process, with the only exception of selecting in the 'Align Photos' option window, select in the 'Advanced' drop down option to 'Apply masks to: *Key points*'.
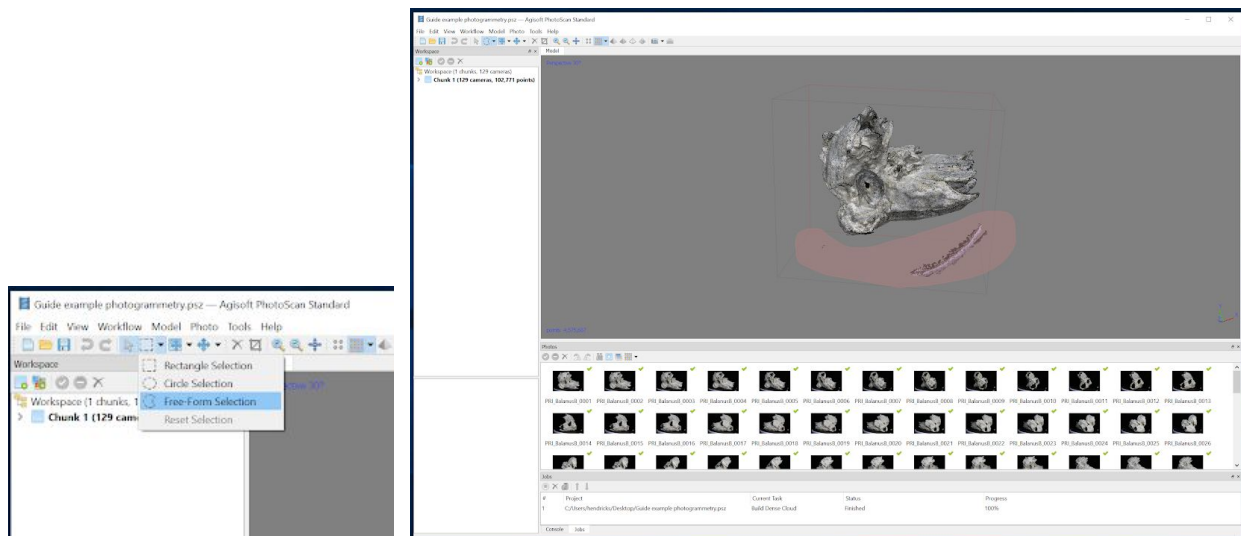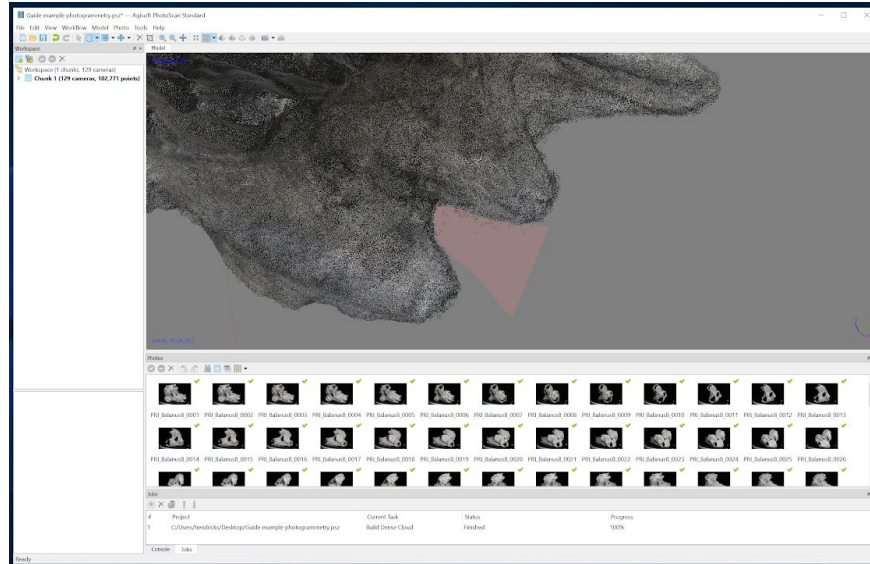
Building Dense Cloud

1. In the toolbar, click 'Workflow' - 'Build Dense Cloud…' - 'OK'
    - This will bring up an options window where the quality at which the dense cloud is created can be chosen.
    - There can be some variance with this selection, but typically 'Medium' will give decent results without taking drastically more time. If the initial model from the photo alignment is sparse, run the dense cloud at a higher quality to give you more points.

    - To view the dense cloud model, select the Dense Cloud icon along the toolbar (the icon with sixteen multicolored dots)

2. If the dense cloud model look correct then select the 'Free-form' selection tool in the toolbar and remove any excess distal points that do not belong to the model. This is done by clicking and dragging the cursor to select an area of points. The highlighted area and points selected will turn red. This is the same clean up process as the photo alignment process, but this model is able to be cleaned up more intensely to remove any excess points.
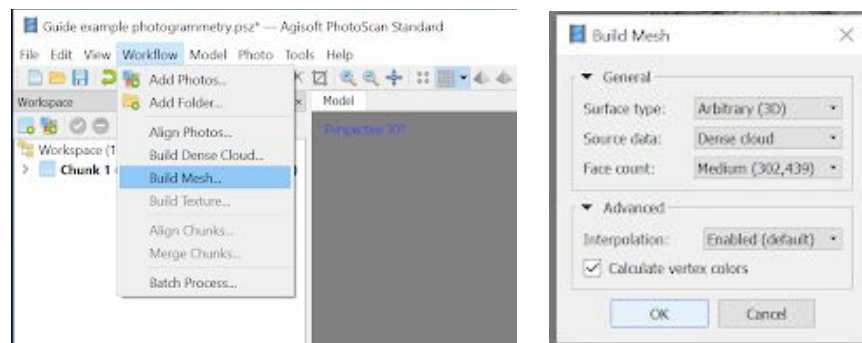
- Once finished with the editing make sure to save!

Building Mesh

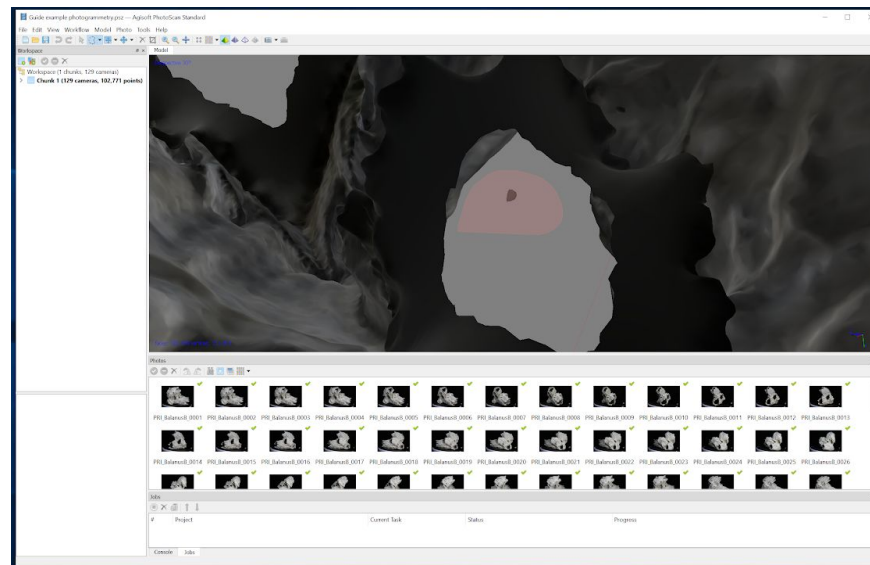1. In the toolbar, click 'Workflow' - 'Build Mesh…' - 'Face count: *Medium'* - 'OK'

2. Once the mesh is finished, select the first yellow and green pyramid icon along the toolbar to view the mesh model.

**The rest of the mesh editing will be user preference as to how to make it look the best.

- During the mesh processing there could have been excess dense cloud points that were transfered into the mesh model as flying blobs. These can be deleted with the same 'Free-form' selection tool in the toolbar as in both the photo
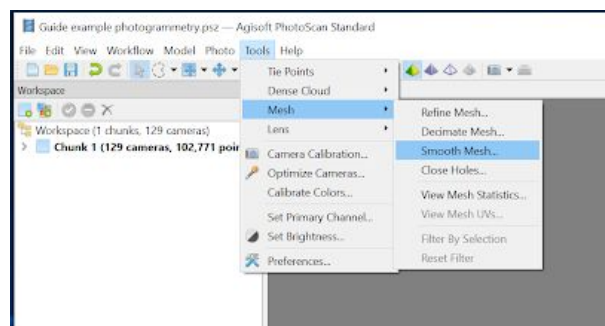
alignment and dense cloud editing.

** This image was taken from within the mesh of model because the free-form selection tool will select mesh on all plains of the model if facing into the model.

- If there is a edge or surface with a bit of mesh that is undesired, use the free-form selection tool to highlight and delete the area. The edges should be smoothed slightly and then the hole(s) should be closed. It is easier close all holes at once after all undesired mesh has been removed from the model.
- If there is significant errors in the model consider restarting with a new alignment, if the errors cannot be fixed with deleting or smoothing the problem area.
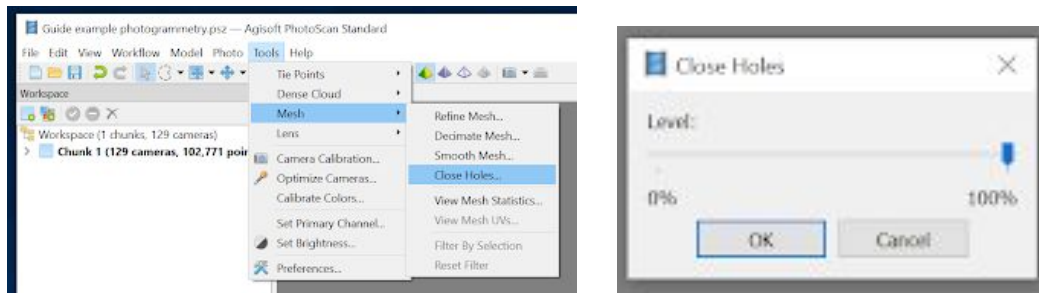
Smoothing the model:
- Along the toolbar, select 'Tools' - 'Mesh' - 'Smooth Mesh…'
    - This is user preference to as to strength level of smoothing. Levels 1-3 are minimal change, 4-5 are more noticeable change, 6-9 very noticeable change, 10< drastic change.
    - A specific area of the model can be selected with the free-form selection tool to be smoothed separately from the rest of the model by selecting ' Apply to selected faces' in the 'Smooth Model' option window.

**There is no undo option for smoothing, so smooth less than it needs and if it needs to be smoothed more, repeat the process again. Make sure to save model before beginning the smoothing process.

Closing holes on the model:
- Along the toolbar, select 'Tools' - 'Mesh' - 'Close holes…'
  - Most holes will need to be at '100%' to close - this does not affect anything. The larger holes need a higher the percentage.
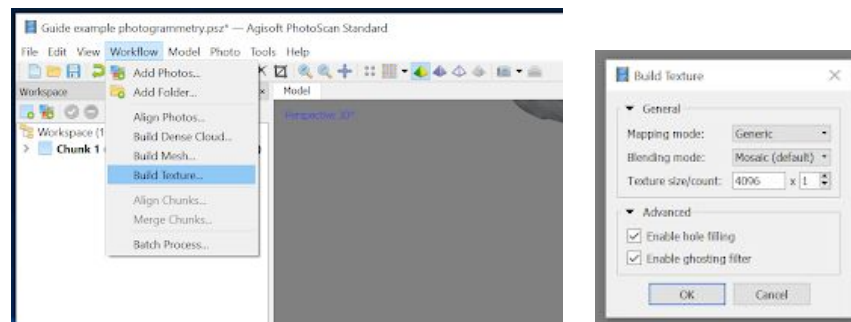

** Some edges of the closed holes will not match exactly to the rest of the mesh, this could possibly be fixed by smoothing the entire mesh slightly. If not, remove the closed holes and either remove more of the surround mesh of the undesired area or try to smooth the original mesh to a desired shape.

**If there is a problem area of the model that is too rough to smooth, the entire area can be deleted and then masked. Be aware this will possibly change the shape of that area if it is on a corner or distinct feature of model. Flatter surfaces work best for this option.
- Remove undesired mesh - smooth edge mesh - close hole

Building Texture
1. In the toolbar, click 'Workflow' - 'Build Texture…' - Mapping Mode: 'Generic'
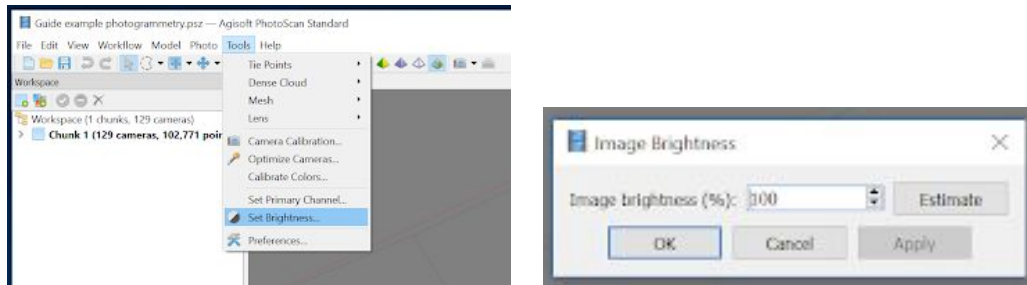

**There is limited editing that can be done to the texture itself.

Once the texture is finished, select the last pyramid icon (with the sky and tree) along the toolbar to view the model with texture.

If the overall exposure of the model is too bright or too dark:

- Along the toolbar, select 'Tools' - 'Set Brightness'.
  - Lower the percentage if too bright and raise the percentage if too dark.
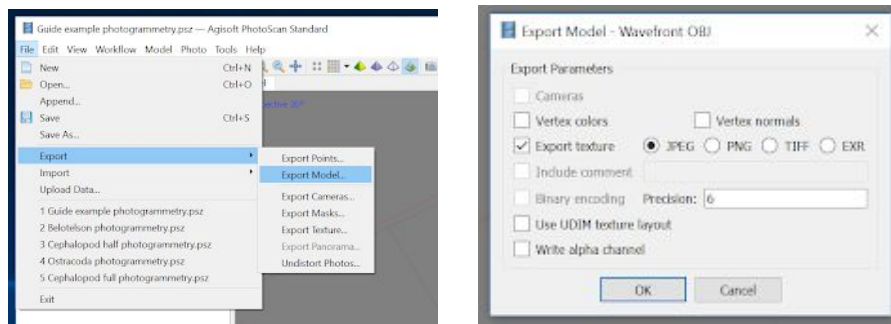

If there is a section or edge of the model that is black:
- Return to the mesh model and try to find and remove the area, and then build the texture again. If that does not fix the area, assess the overall model and determine if the dark area diminishes the quality of the model.
- If does diminish the overall quality of the model, taking another round of photos highlighting the area with the dark/shadow may also fix this problem. These photos will need to be added into the original chunk and the process will need to be repeated from the beginning.
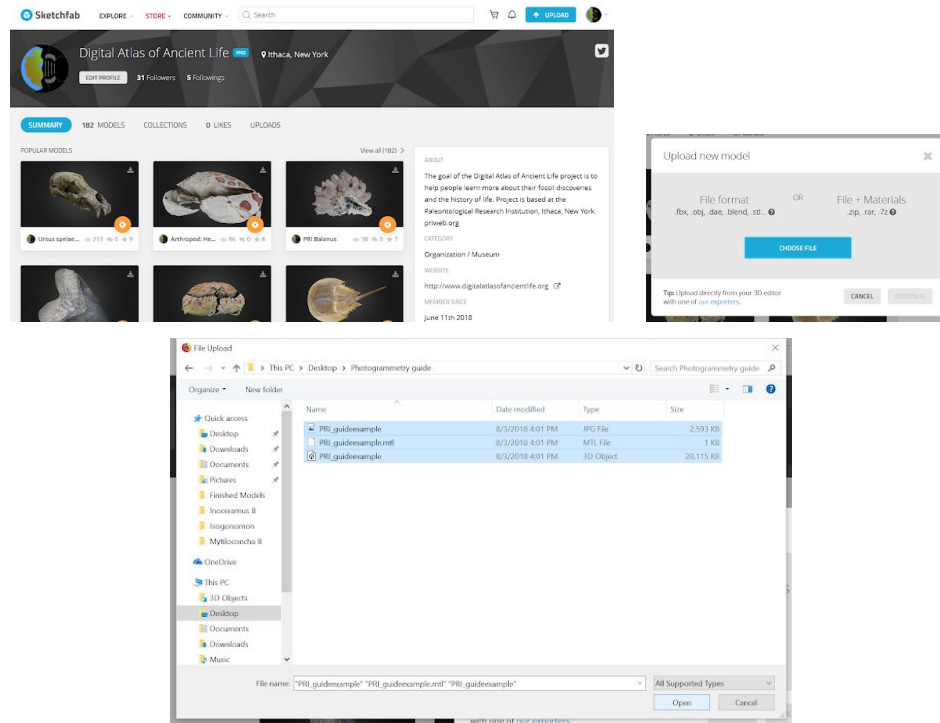
Exporting Model
1. Along the toolbar, select 'File' - 'Export' - 'Export Model…'
2. Select the folder of the specimen and then save the file as 'PRI_*Specimanname*' (file type: .obj)
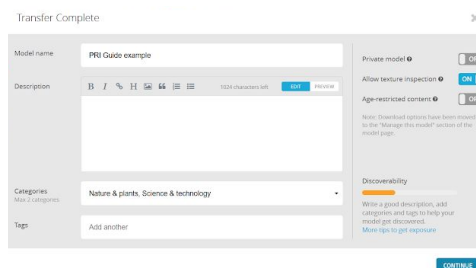3. Deselect Vertex colors and export texture as a jpeg.
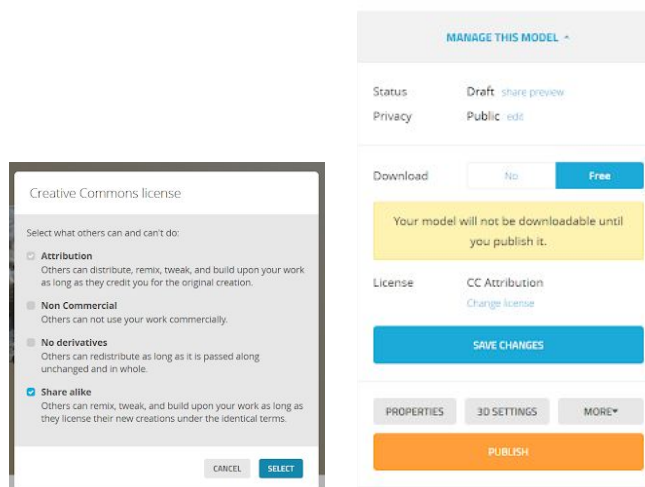

Part III - Publishing to Sketchfab

1. Select 'Upload' - 'CHOOSE FILE' - select desired files (these should include: JPG File, MLT File, and 3D Object) - 'Open' - 'CONTINUE'.

2. Add description, categories, and tags that best fit the specimen - 'CONTINUE'
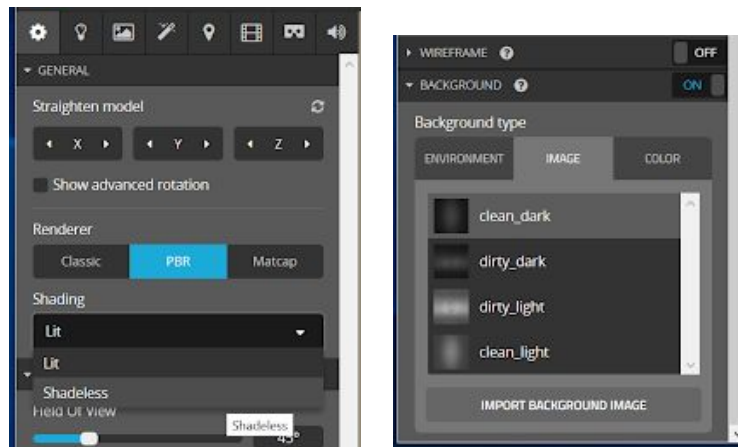   - Typical categories used are Nature & Plants and Science & Technology.

3. Change Download to 'Free' with 'Share alike' Creative Commons License
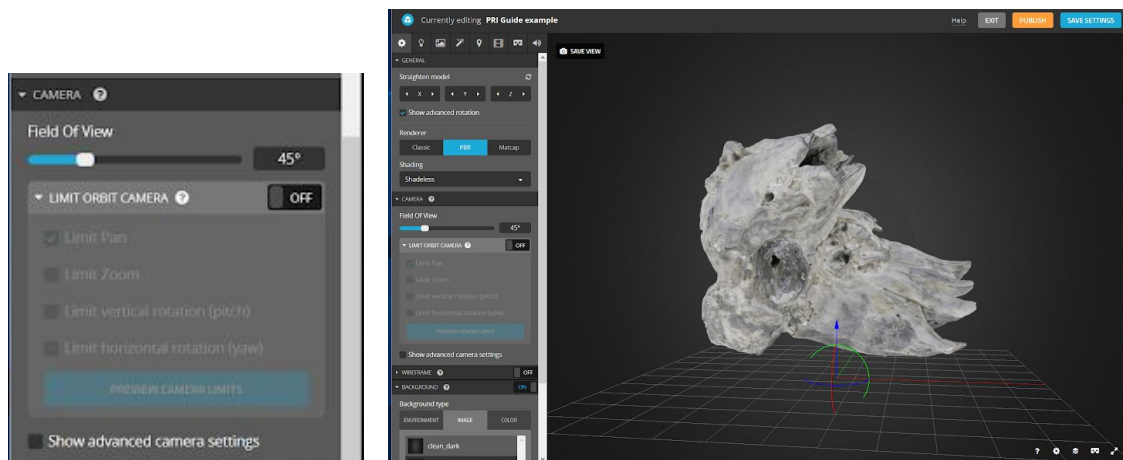

4. Select '3D SETTINGS' - in 'General' under 'Shading' selected 'Shadeless'

5. In 'General' under 'Background' selected 'Image' and select 'clean_dark'

6. If the original position of the 3D model needs to be changed, select 'Show advanced rotation'.
   - If the camera view needs to be limited, turn 'LIMIT ORBIT CAMERA' on and either select 'Limit vertical rotation' or 'Limit horizontal rotation'. Limiting the pan will not allow to move the model from the original axis.

7. Once the model is placed in the desired position. Click 'SAVE VIEW', which will also save the other edits made to the model on Sketchfab. Once this is finished, 'PUBLISH' can be selected - the model's web page will load and the finished and published model will be able to be viewed.