Lab 11: Close-range Photogrammetry

Objective

The main goals of this lab are to familiarize students with:

- How structure from motion (SfM) photogrammetry can be applied to 3D object scanning
- Tools in Metashape for modeling 3D objects from 2D photographs
- Working with 3D meshes for modeling objects and calculating volume and surface area

To this point, we've worked exclusively with drone imagery to create map products from aerial photographs. However, the SfM techniques work the same for creating 3D models of objects from regular photographs too. The approach is slightly different, where you either orbit an object, taking pictures from all sides (not too different from what we might do from a drone), or you keep the camera in a fixed location and rotate the object (much different than what we typically do with a drone!). In this lab, we're going to create a 3D model of my Darth Buddha figurine that was created on a 3D printer. We'll create a 3D model and then estimate the volume of Darth Buddha.

Deliverables

Fill out and submit the questions at the end of this document. ***No need to submit a quality report from Metashape.***

Section 1: Load photos and set coordinate system

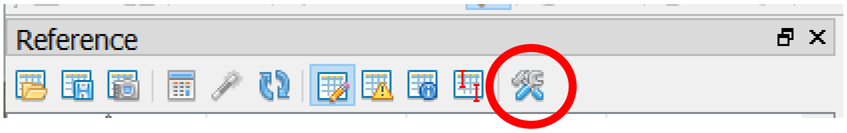
1. Download the images that we'll need for this lab from the following link: https://vandalsuidaho-my.sharepoint.com/:u:/g/personal/jkarl_uidaho_edu/EX67FJ22XE9PodWMaY7sg6sBDZ2cs2cQLgGLN8A69b5WBg?e=2MSWpk

2. Also, download the following files from the class BBLearn site and save them to the folder where you're going to save the Metashape project for this lab:
    a. Turntable_Targets_Metashape_Markers.csv
    b. Local_mm.prj

3. Open a new Metashape project and load the photos for this lab.

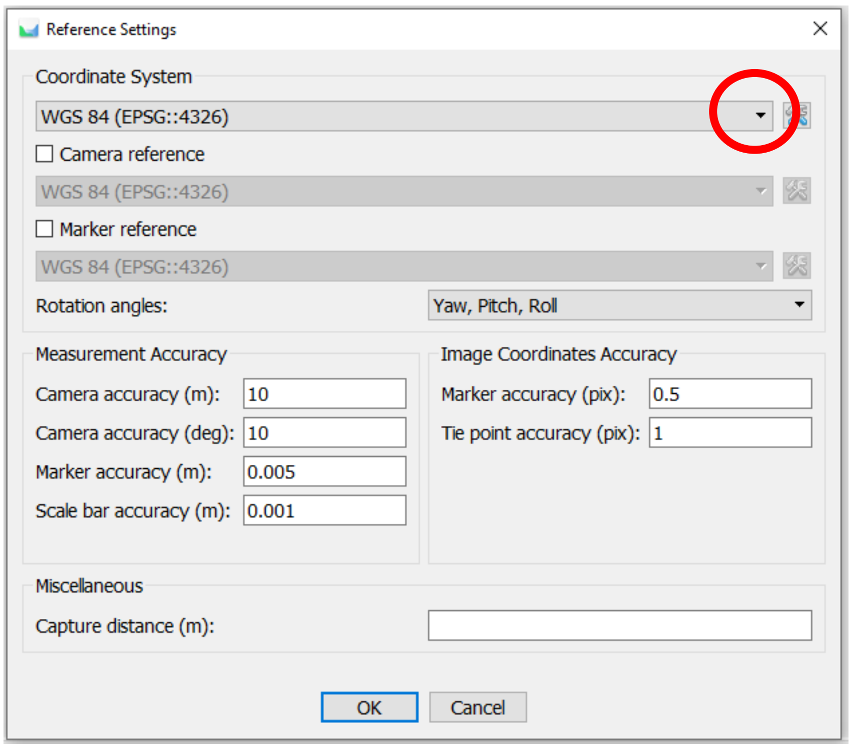
4. With all our past Metashape projects, we've worked with drone imagery that had geographic coordinates associated with it (or for which geographic coordinates were appropriate). For this lab, though, geographic coordinates aren't appropriate for two reasons: 1) we're working at a very fine scale to model an object, and 2) the camera is fixed and the object is being rotated. For these reasons, we need to establish a local coordinate system for this project. Metashape has one local coordinate system available, but its units are in meters – which is also too coarse for what we're doing. So, we'll load up a new coordinate system that uses millimeters for units.

    From the reference pane, click on the Reference Settings button.

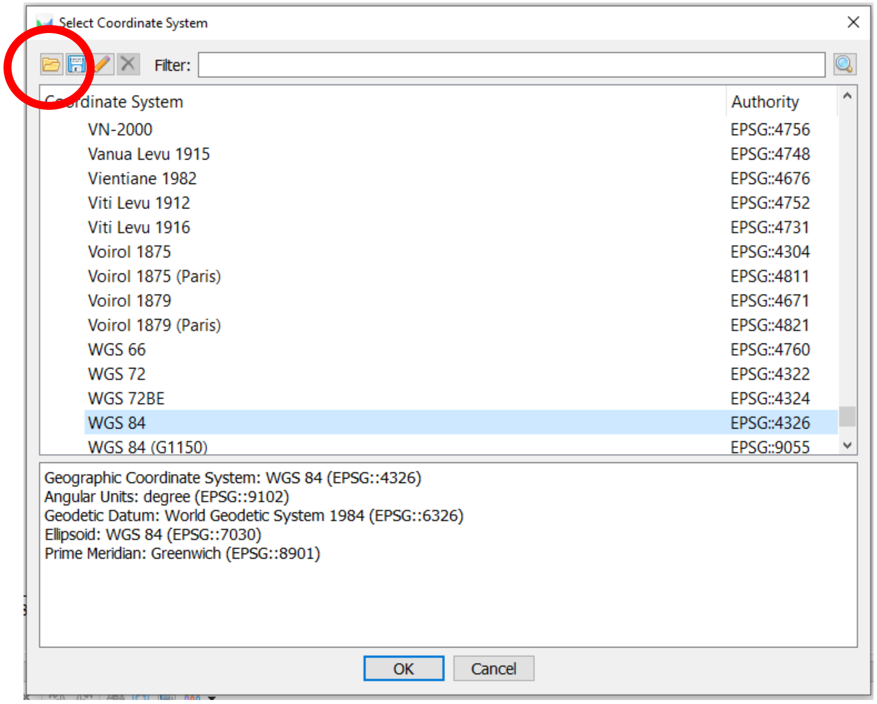


5. Notice the Coordinate system is set to WGS 84 (EPSG::4326). This is the default for GPS coordinates that are normally associated with drone imagery.

   Click on the down arrow and choose "More…"



6. This dialog box lists all the available coordinate systems (yes, there are a lot of them!). However, the one we want isn't there. Click on the folder icon and select the Local_mm.prj file. Click Open. Click OK to close the Select Coordinate System dialog.

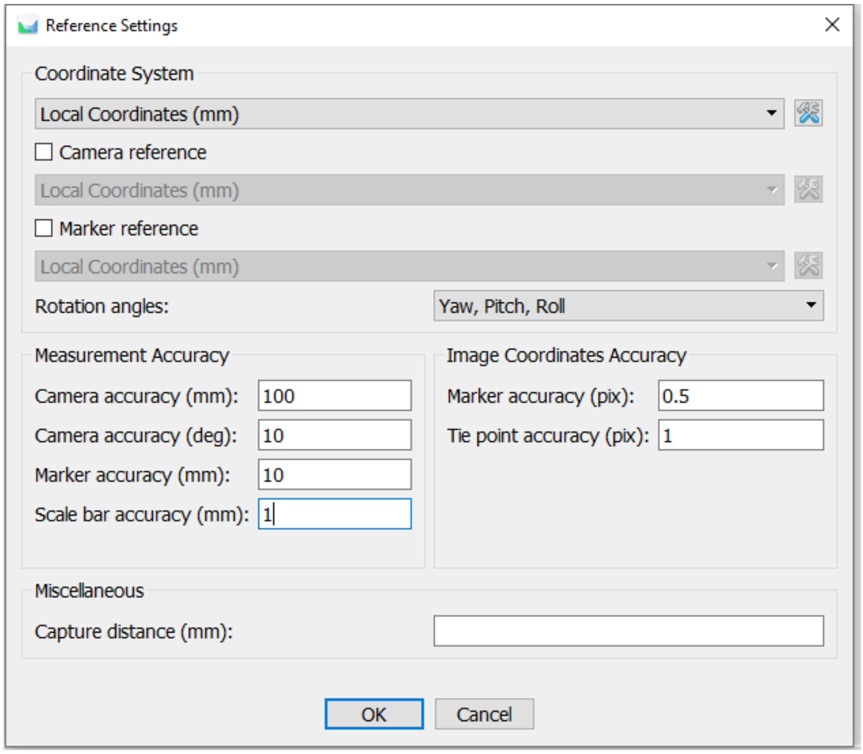


7. You'll notice that the coordinate system is now changed, but all the units on the Reference Settings dialog are still set to meters. We need to accept the change and then reopen this dialog to see the changes.

   Click OK to accept the change of coordinate system and then reopen the Reference Settings dialog box.

8. Notice now that the units on this page (e.g., Camera accuracy) are now listed in millimeters. Because we're confident that the camera position is fixed and the reference markers on the turntable are accurately placed and measured, we can dial in our measurement accuracies.

   Change the Camera accuracy to 100 and the Marker accuracy to 10. Click OK to close this dialog box.

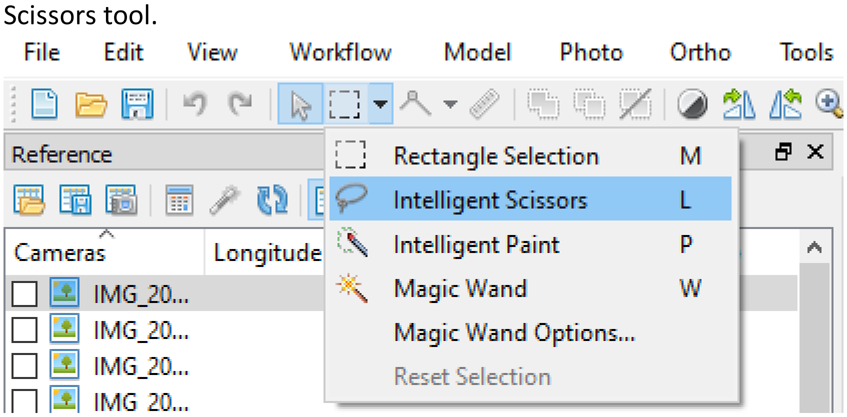


Section 2: Masking and aligning the photos

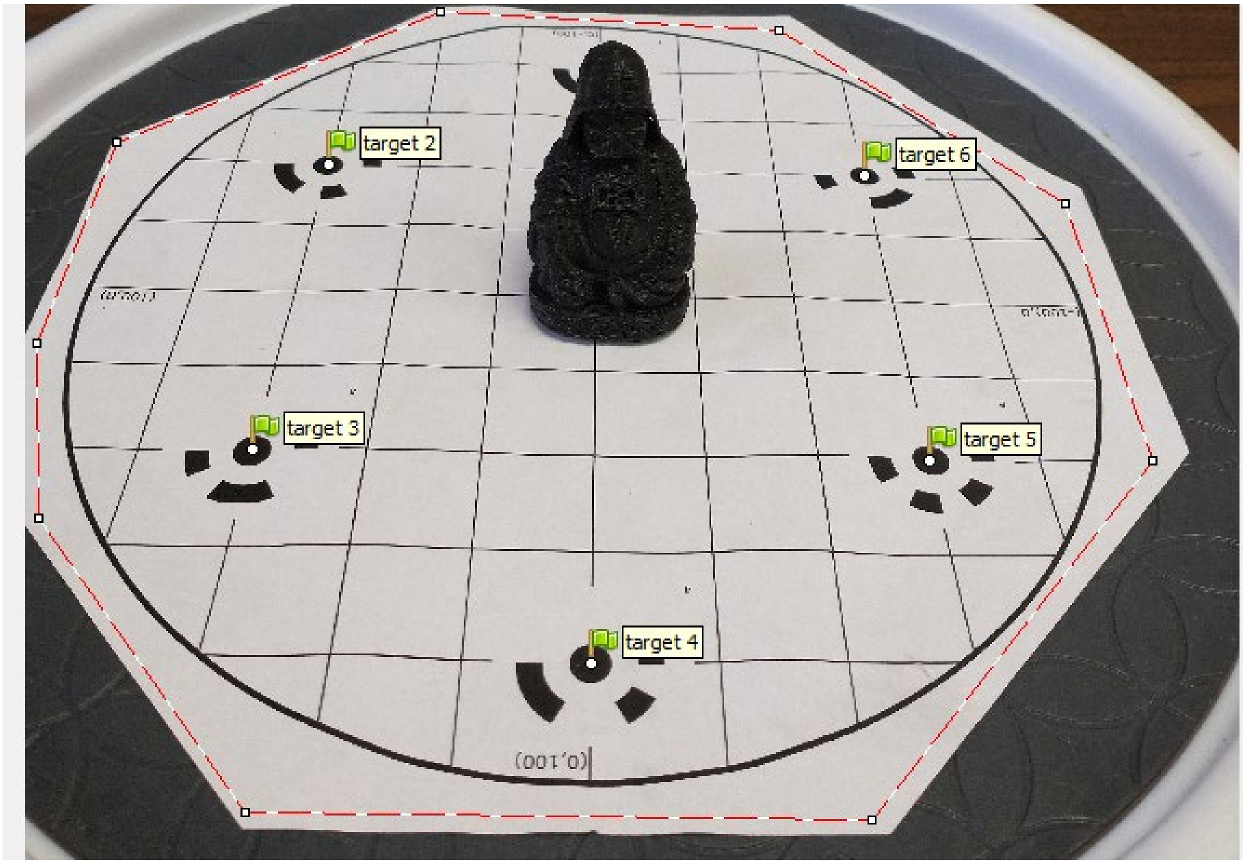
Before we can align the photos, we need to deal with the background of the photos that doesn't move as the turntable is rotated. We need to instruct Metashape to ignore this part of each photo otherwise it will interfere with the alignment process (i.e., the photos won't align). We do this by creating a mask.

1. Open one of the photos by double-clicking on it in the Photo Tray.

2. From the main toolbar, click the drop-down next to the selection tool and choose the Intelligent Scissors tool.

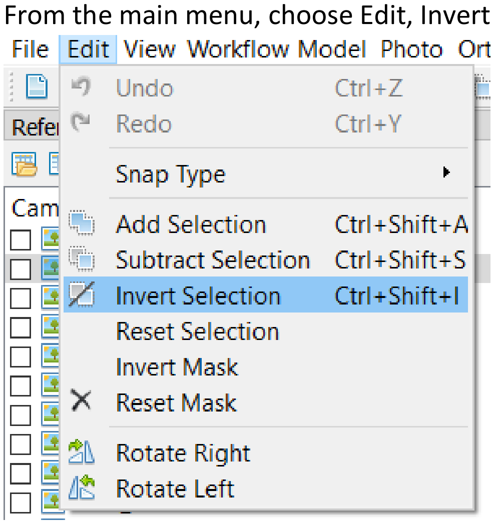


3. Use the Intelligent Scissors tool to digitize a polygon around the circle of the turntable, staying on the white part. No need to be super precise here, just get the basic shape.

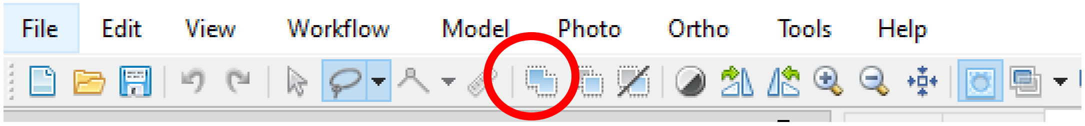


4. This tool has created a selection of the area WITHIN the polygon. We need to mask the area OUTSIDE the polygon. To do that, we need to invert the selection.

   From the main menu, choose Edit, Invert Selection.

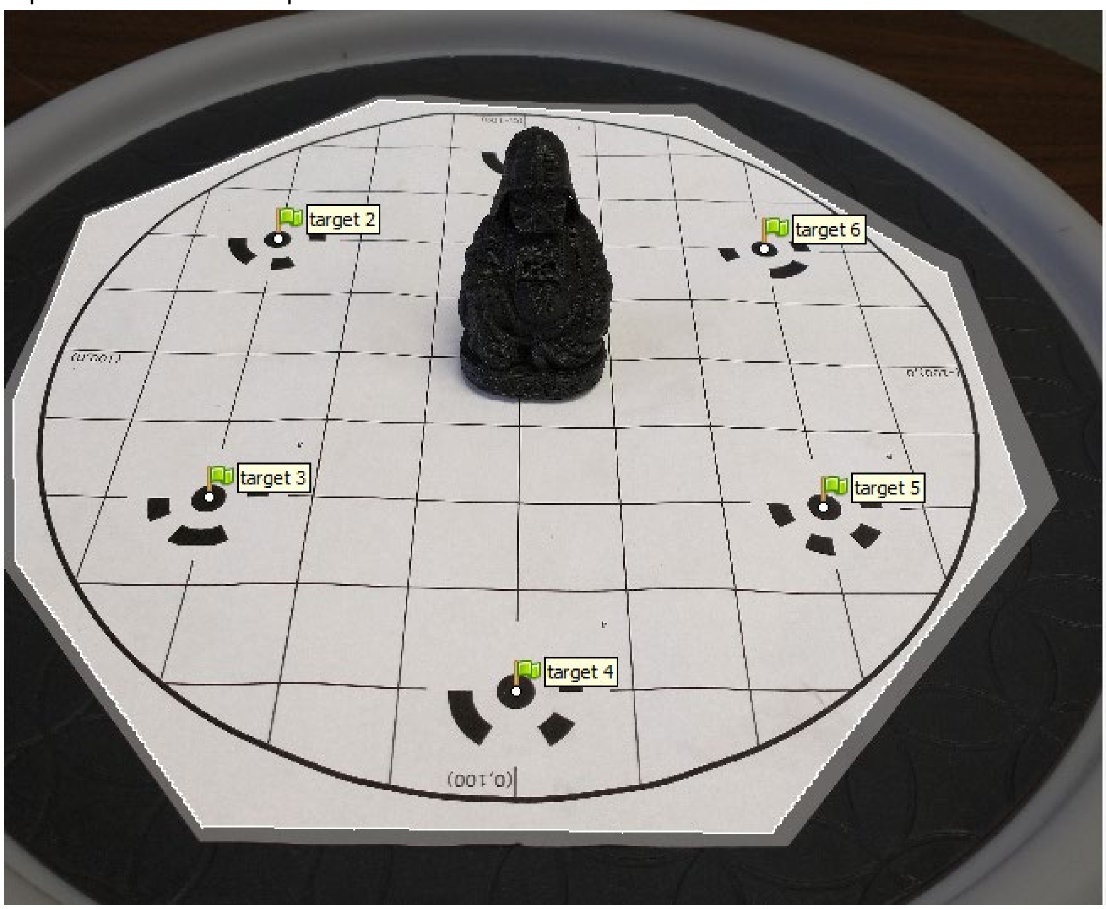


5. Now add the selection (which includes everything EXCEPT for the turntable) to the mask by clicking on the Add Selection button on the main toolbar.



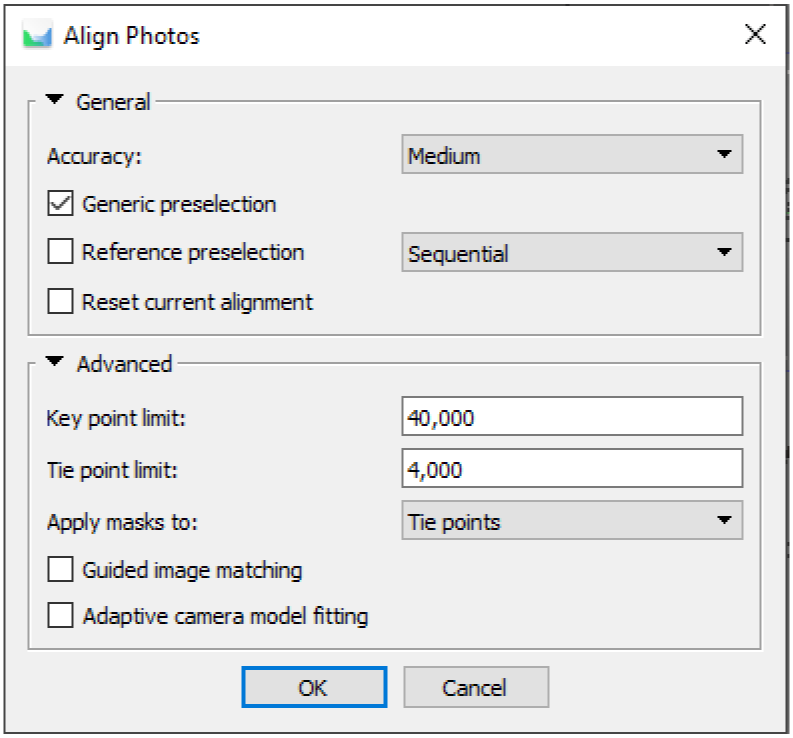
6. Your finished mask should look something like below. Note that the shaded-out portion is masked out and will not be considered for matching tie points.

   Also note, because we have a mask region that is very consistent among our photos, we only need to create the mask on one photo. If the background changed between photos (i.e., the object was stationary and we moved around it to take the photos), we would need to create a separate mask for each photo.



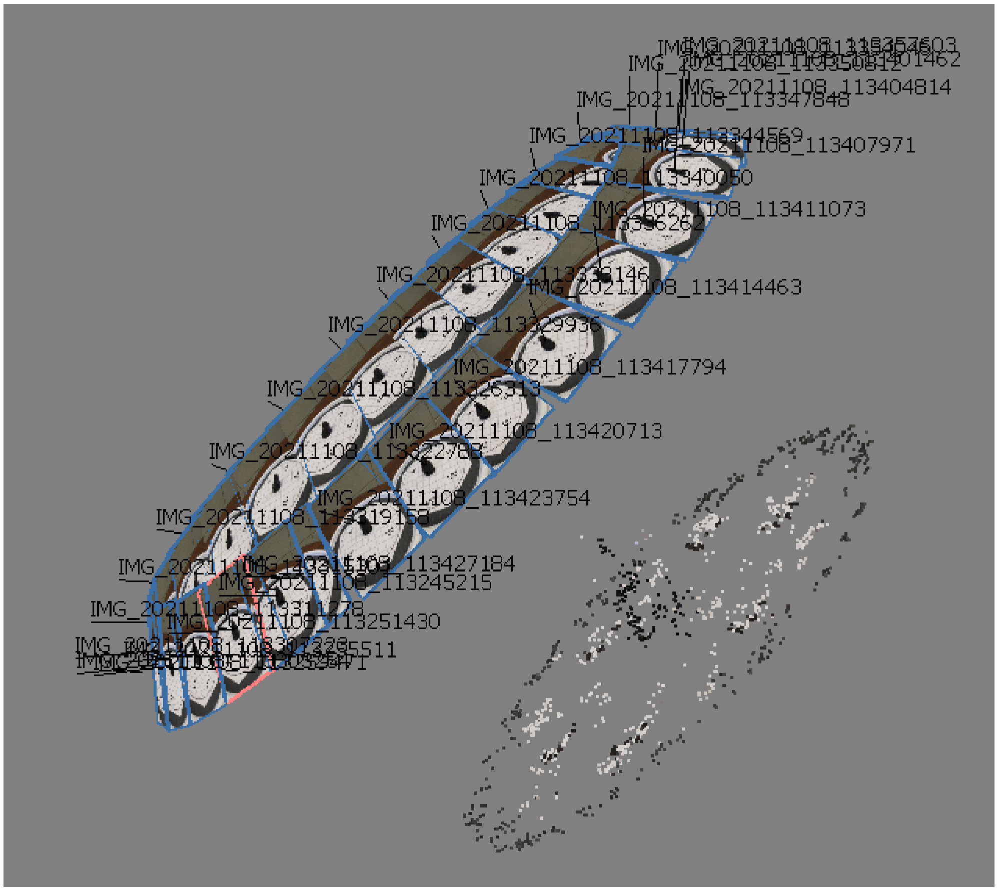
7. Now we can align the photos. From the main menu, choose Workflow -> Align Photos.

   This process is pretty much like we've done before with just a couple of changes. First, there is no geographic coordinate information for the photos, but the photos are in sequence, so choose Sequential from the drop-down menu. Second, change the option to apply masks to the Tie Points. Check the other options against the figure below, then click OK.



8. When your photos have aligned, you should have a sparse point cloud that looks something like this. The orientation of the sparse cloud may be off. This is because there is no reference

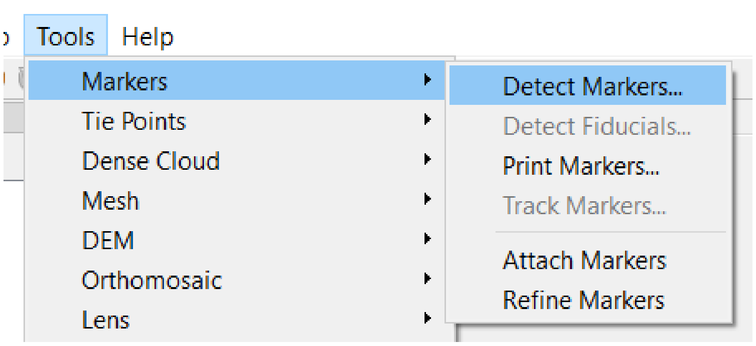
information yet to tell Metashape which direction is up. We'll add that next.



Section 3: Detecting markers and adding "ground" control

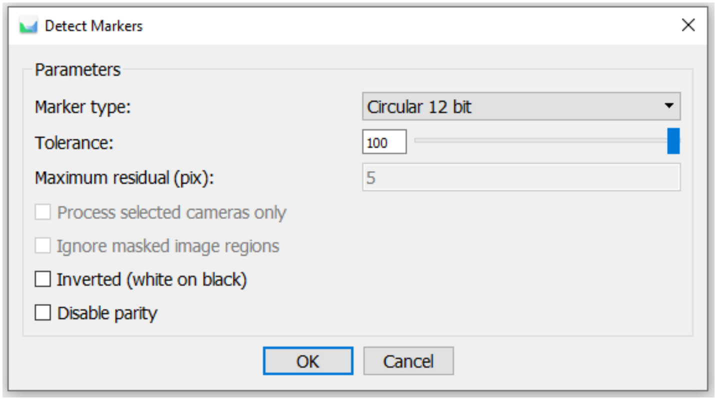
The next step is to add some "ground" control. This will scale the model so we can get accurate measurements and will tell Metashape how to orient the model (i.e., which way is up). The targets and the grid on the turntable are critical for this (and actually make it pretty easy!).

1. The first step is to have Metashape detect the targets on the turntable. From the main menu, choose Tools -> Markers – Detect Markers.

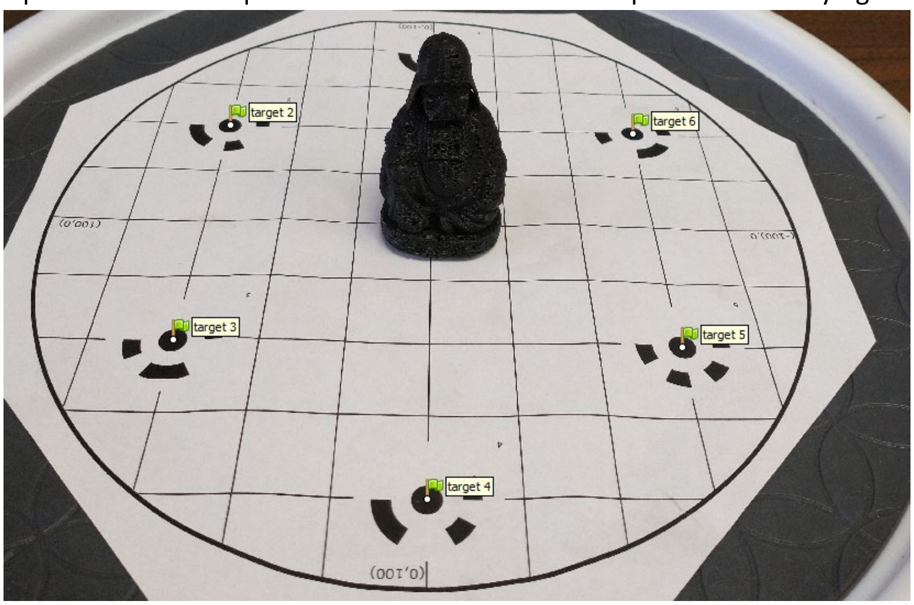


2. Make sure the marker type is set to Circular 12-bit, and set the tolerance all the way up to 100. Click OK, and Metashape will scan each of the photos for the targets and create a marker for

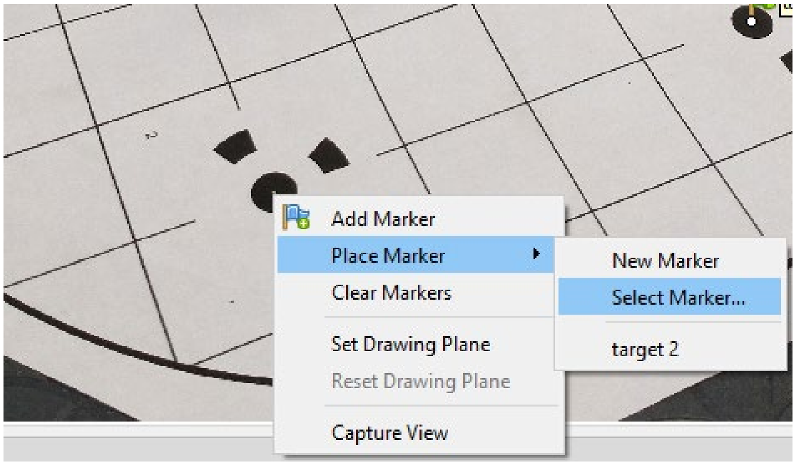
each one.



3. Open several of the photos to see how well Metashape did at identifying the targets.



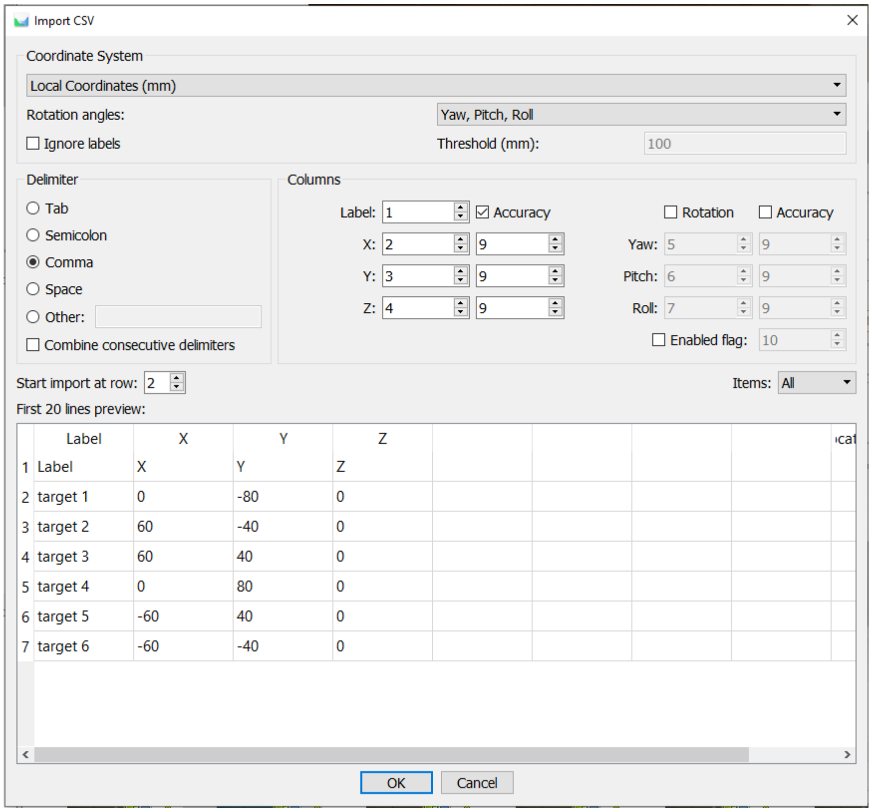
For some reason, it seems to have trouble identifying target 2 in some photos. In these cases, you can manually place the marker on the photo by right-clicking where the marker should go and choosing Place Marker (note: make sure you've switched back from the Intelligent Scissors tool to the navigation (pointer) tool).



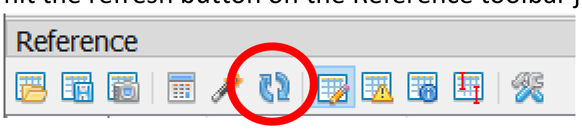
Spend some time looking through the remainder of the photos checking and where necessary fixing the markers.

4. With the markers identified on the photos, we next need to import the coordinate information. The grid on the turntable establishes a Cartesian coordinate system with it's origin (0,0 point) at the center of the turntable (under Darth Buddha). From the reference window, click on the Import Reference button.

5. Import the Turntable_Targets_Metashape_Markers.csv file. Make sure you set the Coordinate System to Local (mm) and set the columns to match the data in the file. Click OK to import the coordinates for each target/marker.



6. Everything should update to reflect the new coordinate information, but it's not a bad idea to hit the refresh button on the Reference toolbar just in case.

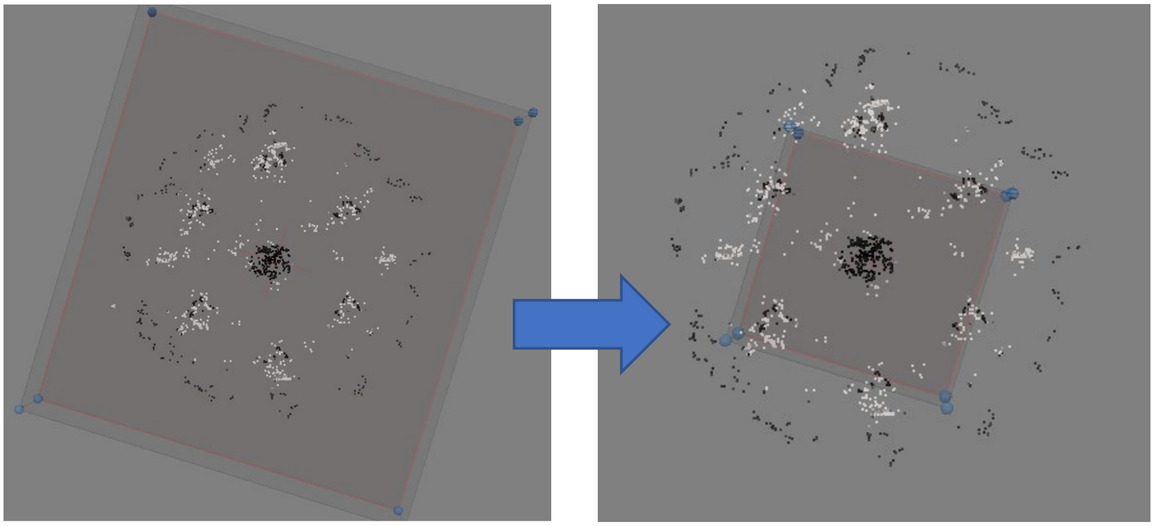


Section 4: Resizing the region and building a mesh

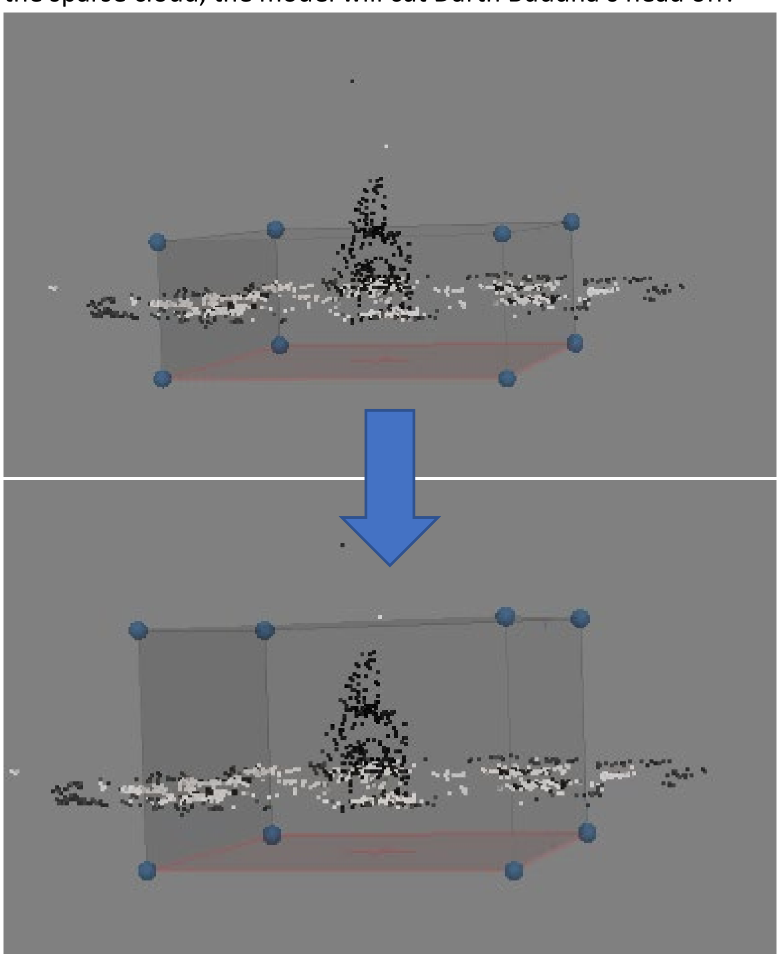
At this point with a normal drone mapping project, we would build a dense point cloud, then a DEM and orthomosaic. For this application, though, a Mesh 3D model is going to be more helpful. Before we get there, it's helpful to shrink the analysis region to get rid of some unnecessary parts.

1. From the main toolbar, click on the Resize Region button (you may need to use the drop-down arrow to get to this tool.

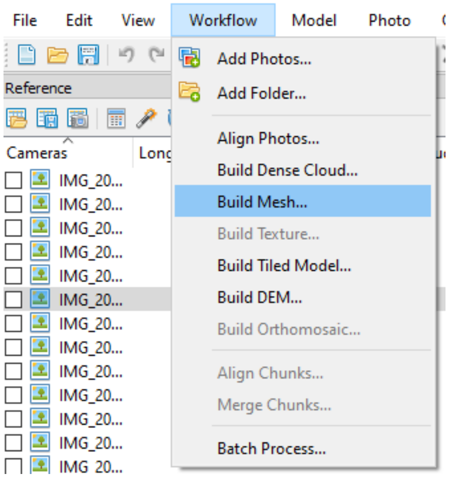
2. Shrink the analysis region by grabbing the corners of the box and dragging them in toward the center. Try to just trim off the outside of the turntable. If you make it too small, Metashape won't be able to build the Depth Maps it needs to make the Mesh model. If that happens (you'll get an error box), make your region bigger.



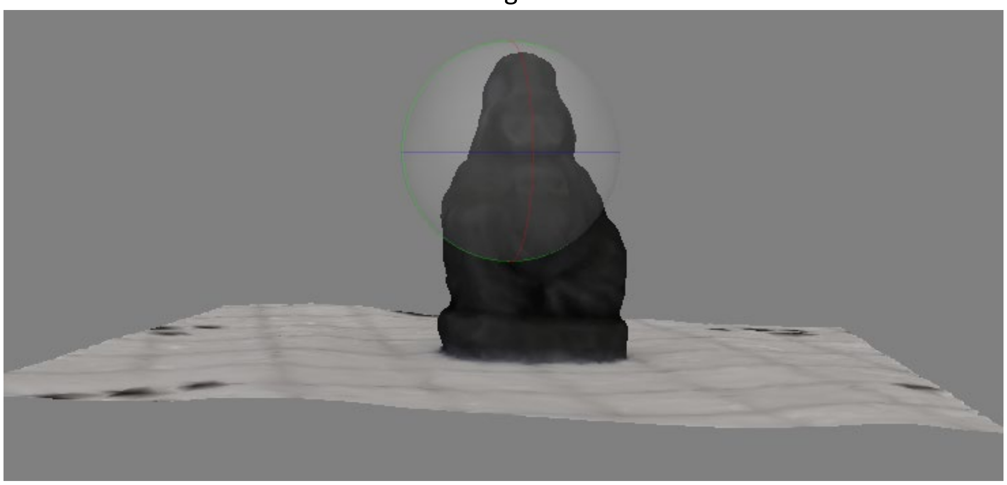
3. Make sure you view the region from the side too. If the region does not extend all the way up the sparse cloud, the model will cut Darth Buddha's head off!



4. When the region has been set, choose Workflow -> Build Mesh from the main menu.



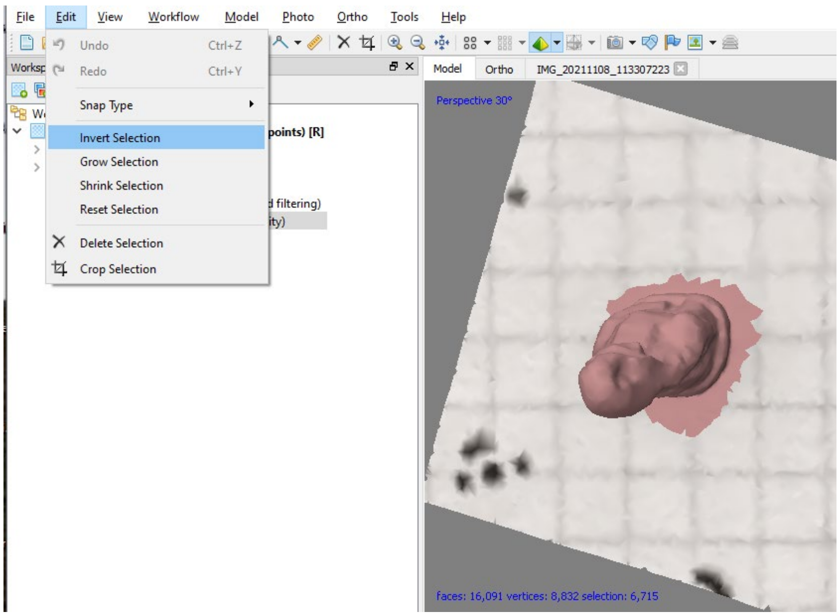
5. The 3D mesh model should look something like below.



Section 5: Trimming the mesh and calculating volume

The final step for this lab is to estimate the volume of the Darth Buddha. To do this, we'll first want to trim the rest of the turntable off of the model.

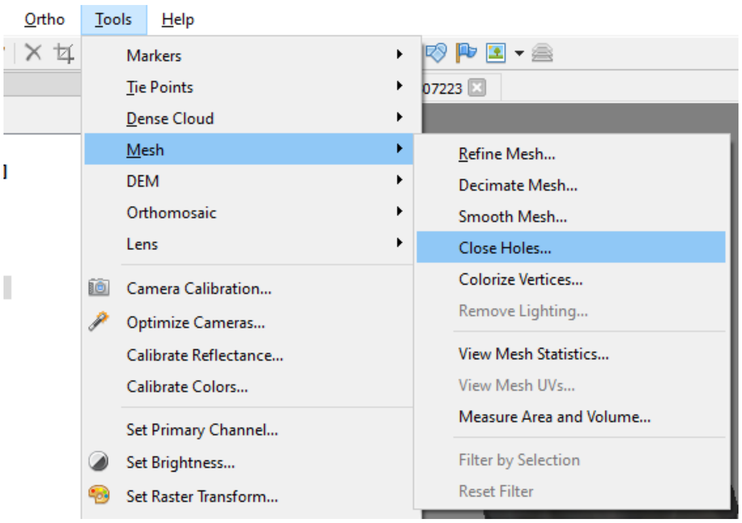
1. Use one of the selection tools from the main toolbar to select Darth Buddha and a little of the surrounding turntable surface. Then from the main menu, choose Edit -> Invert Selection. This will switch the selection to the rest of the turntable and leave Darth Buddha and the nearby turntable parts unselected.



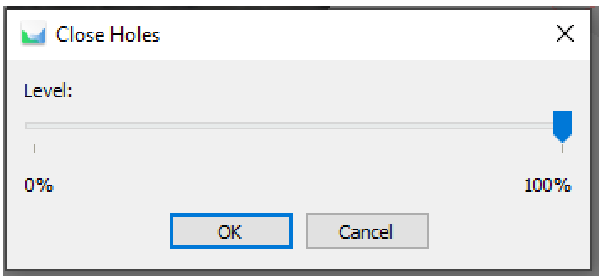
2. Click the delete button on the main toolbar to delete the selected portions of the turntable (not Darth Buddha!).

3. Zoom in around the base of Darth Buddha and select the remaining patches of turntable and delete them. You should be left with a relatively clean model of just Darth Buddha.

4. At this point, if you turn Darth Buddha upside down, you'll see that he's hollow. To calculate the volume, we need to have a solid/enclosed model. To do that, from the main menu, choose Tools -> Mesh -> Close Holes.

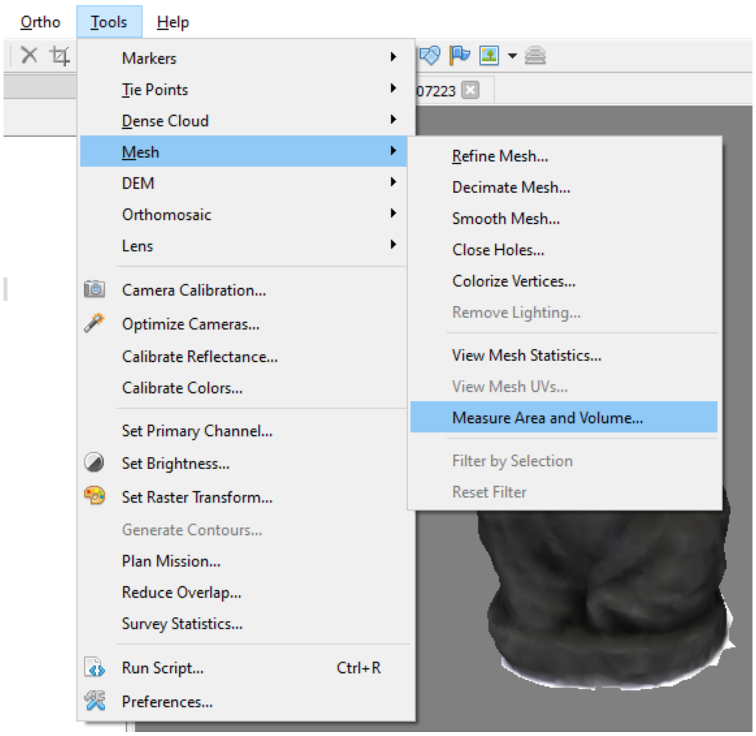


5. Set the level to 100% and click OK.

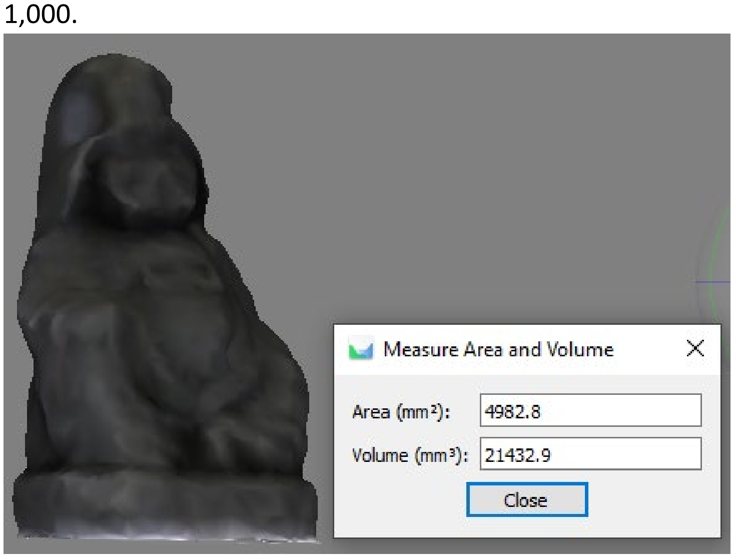


6. You should now see that Darth Buddha is solid.

7. The last step for this lab is to calculate the volume. From the main menu, choose Tools -> Mesh -> Measure Area and Volume.



8. The volume in cubic millimeters will be shown. Convert this to cubic centimeters by dividing it by 1,000.



Lab Questions to Answer

Please answer the following questions and where appropriate provide justification for your answers.

1. What was your volume estimate for Darth Buddha (please make sure to include the units)?

2. Include a screenshot of your Darth Buddha mesh model.

Lab Grading Rubric

Question	Points
1	_____ / 15
2	_____ / 15
Total	**_____ / 30**