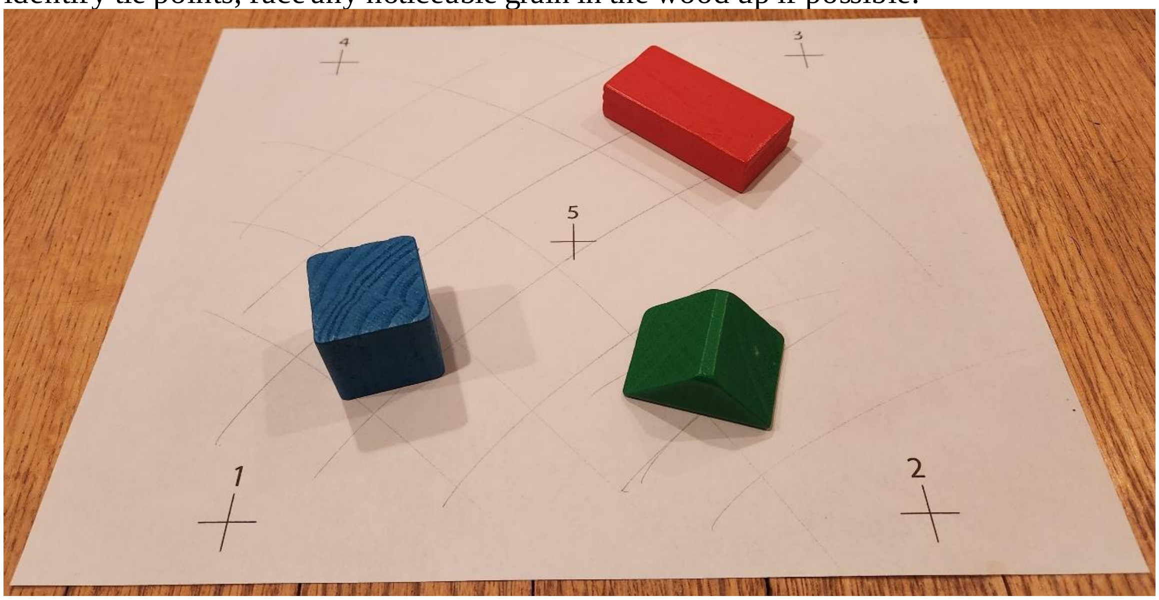
Geological modeling
Week 2 – 09/19/2022
Photogrammetry with Pix4Dmapper

Create and photograph physical model

1. The printed sheet with 5 marks on it will define an arbitrary coordinate system for the 3D model that we will create with Pix4d software. The first 4 marks create an 18 cm x 18 cm square, the 5th is in the center of that square. These marks will serve as control points for the 3D model. Using this sheet of paper, we will calculate the dimensions of a few objects placed on top of it.
2. As a first step, scribble a few lines on the sheet of paper, this will help the photogrammetric software generate tie points to correlate between photos.
3. Place 2-3 of the colored blocks onto the sheet of paper. Include one of the 3 cm x 3 cm cubes. More texture on the face of the object will help the photogrammetric model identify tie points, face any noticeable grain in the wood up if possible.

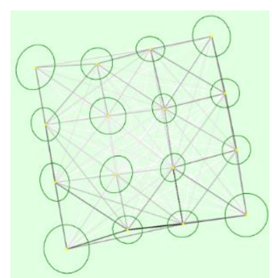


4. Once you have laid out the physical model, take a maximum of 16 photographs of the scene. A better model can be created with more photos, but this limit is necessary due to computational/time constraints.
   a. Taking the photos with the camera facing straight down in a manner that maximizes overlap of adjacent images will work, i.e., moving the camera in a 4 x 4 grid approximately 10 inches above the paper (~66% forward and side overlap).
   b. Other techniques utilizing oblique angles may improve the result. Briefly describe your approach to photographing this physical model.
   c. Estimate what percentage of each photo overlaps the adjacent photo in both directions (60 to 80% will yield good results). Turing on the grid to your camera may be helpful in making this estimate.
   d. Save these photos in a directory named "lastname_3Dphotos_20220919".
5. Take a 17th photo like the one above and save it in a separate folder for reference later.

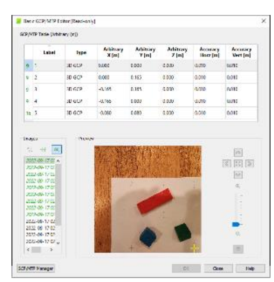
Photogrammetry with Pix4Dmapper

Create digital model

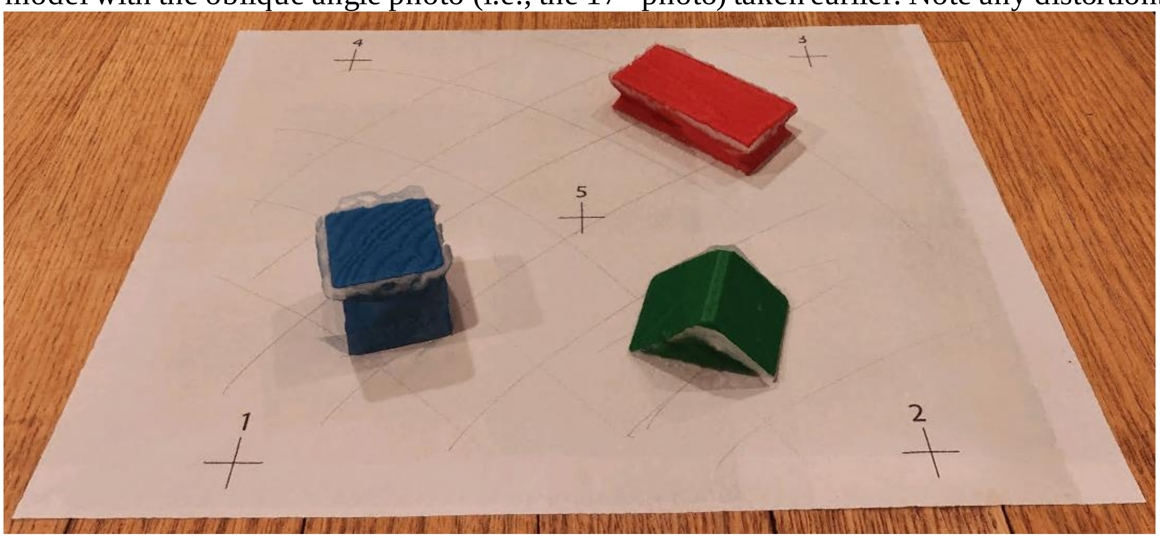
1. Open Pix4SchmelzD and create a new project.
2. Name the project “lastname_3Dmodel_blocks”
3. On the “Select Images” screen, select “Add Directories…” and choose the folder that you saved your 16 photos in.
4. On the “Image Properties” screen:
    a. “Edit…” the coordinate system, choose arbitrary.
    b. Clear the “Geolocation and Orientation” data from the image files. The Arbitrary X, Y, and Z should now show 0.00 m.
    c. Note the pixels in each image in the “Selected Camera Model” window.
5. The next screen allows you to choose an output coordinate system. It should default to “Arbitrary”. Click next.
6. In the processing options template, choose “3D Maps” and select “Finish”.
7. Next, click on “Processing Options” in the lower left corner of the screen.
    a. Toggle on only “1. Initial Processing”, and in the menu for the initial processing step choose “Custom” for the “Keypoints Image Scale”.
    b. If the size of your camera image was greater than 5000x3700 pixels, choose 1 (Original image size). If it was less, you can choose 2 (Double image size).
    c. Select OK.
8. Choose “Start” in the “Processing” toolbar. The operation took me 5 min 21 seconds using images with ~4000x3000 pixels while doubling the image size. If this step takes longer than ~10 minutes, try choosing 1 (Original image size).
9. Once this step is finished, it will produce a “Quality Report”. You can find a PDF version of the report in the “%project path% \1_initial\report” folder.



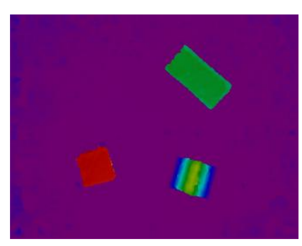
    a. Note the processing time, the number of calibrated images, and the number of matches per calibrated image.
    b. You will want to see 4 green check marks in the “Quality Check”
    c. Browse throught the rest of this report.Figure 4 shows the spatial variation in the number of overlapping images. More overlapping images in the area of interest is ideal. Figure 5 shows the image positions and the number of tie points to other individual photos. Ideally, each of the 16 images should have numerous ties to the other images.
10. Next, select the Project menu and choose “GCP/MTP Manager”. Import the GCP file provided and change the horizontal and vertical accuracy of the GCPs to .01 m.
    a. Click on the “Basic Editor…” button. Assign a mark to 3 photos for each GCP. Do this by highlighting a GCP in the top panel, then selecting an image with that GCP in it in the bottom left panel. Match the crosshairs of your cursor to the crosshairs of that GCP in the image. Click to record and repeat in another image. Select OK when finished assigning three ties for each GCP.



11. Open the “Process” menu and choose “Reoptimize”. Allow the program to rewrite the initial step. This gives the image a spatial reference.
12. This step is optional, note if you choose to apply it. In the rayCloud view, expand GCPs / MTPs and the display properties. Highlight a GCP, and on the right side of the screen a properties window should appear that displays all the images that contain the selected GCP. Quickly mark all of the images, or choose auto identify, and click apply. Do this for each GCP and reoptimize.
13. Open the process menu again and choose to generate another quality report.
    a. Note the Average Ground Sampling Distance (GSD), this is the width of a single pixel in cm. For this lab, it likely rounds up to 1 cm.
    b. You also might receive a warning about the GCPs. Check the “Geolocation Details”. There should be almost no error in the position of the GCPs (<1 mm). A warning is likely related to the projection error, which may be more than a pixel.
    c. Note the RMS error and the projection error of your GCPs.
14. Return to the processing options (bottom left), and highlight “2. Point Cloud and Mesh” and toggle the selection on. Toggle “1. Initial Processing” off.
    a. For the “Image Scale”, choose 1 (Original image size, Slow)
    b. For the “Point Density”, choose “Optimal”
    c. Under Export, choose XYZ and delimiter “Comma”, Merge tiles into one file.
    d. Select OK and start processing. This should take ~6 min.
15. Take a minute to view the Point Cloud and Triangle Mesh surfaces. Compare the 3d digital model with the oblique angle photo (i.e., the 17^{th} photo) taken earlier. Note any distortions.



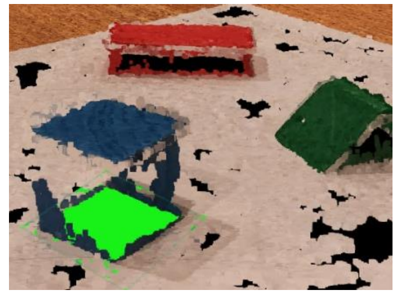
16. Return to the processing options and highlight “3. DSM, Orthomosaic, and Index” and toggle the selection on. Toggle “2. Point Cloud and Mesh” off.
    a. Note the pixel size, leave as default.
    b. Select OK and start processing. This should take ~4 min.



17. View the mosaic image and the DSM by selecting the “Mosaic Editor” view on the toolbar at the left margin of the program window. You can change color bar for the DSM by selecting the

“Mosaic Editor” menu and selecting “Visualization 2”, or by pressing the number 2. Note any distortions to the DSM.

18. Scroll over the paper surface and the objects in the DSM. Is the elevation of the entirety of the paper surface 0 cm? Identify the computed elevation of each of the blocks. Note any difference in elevation to the real-world measurement.
19. Click on the “Volumes ” menu. Create a new volume measurement.
    a. Draw a box around one of the 3 cm x 3 cm cubes.
    b. Click the “Volume Settings” icon and make the base surface a custom altitude of 0 m.
    c. Select compute, copy the volume calculation using the button, and paste into an excel sheet. These cubes should have a volume of ~2.7x10^{-5} m^3. Note the difference between the true volume and the volume of the digitally modelled cube calculated in Pix4d (the “cut volume”).

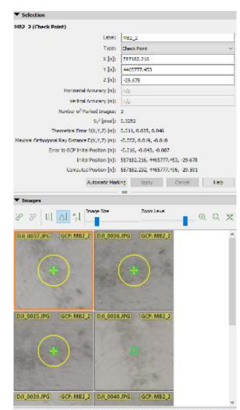


Create model of beach in Monmouth Beach, location of field trip next week

1. Open Pix4SchmelzD and create a new project.
2. Name the project “lastname_3Dmodel_MB”
3. On the “Select Images” screen, select “Add Directories…” and choose the folder that contains 59 drone collected photos of the beach.
4. On the “Image Properties” screen:
    a. Change the “Geolocation Accuracy” to custom.
    b. Highlight all the images in the editor and, with all selected,
        i. Right click on a cell that identifies the horizontal accuracy of the camera position.
        ii. Select “Edit Horz. Accuracies in Selected Rows”
        iii. Change value to 0.5 m.
    c. Reselect all images, right click on a cell that identifies the vertical accuracy of a camera position, and change the Vertical accuracy of all the images to 0.075 m.
    d. It is typical that in most survey applications, vertical error is larger than horizontal. In this case, the horizontal error is larger because the drone is flying ~15-20 m/s. How might a precisely identifying the location of the camera position affect the output?
5. Choose the default coordinate system, and om the in the processing options template, choose “3D Maps” and select “Finish”.
6. Next, click on “Processing Options” in the lower left corner of the screen.
    a. Toggle on only “1. Initial Processing”, and in the menu for the initial processing step choose “Custom” for the “Keypoints Image Scale” and choose 2 (Double image size).
    b. Select OK.
7. Choose “Start” in the “Processing” toolbar. The operation should take ~5 min.

8. Once this step is finished, it will produce a “Quality Report”. You can find a PDF version of the report in the “%project path% \1_initial\report” folder.
    a. Note the processing time, the number of calibrated images, and the number of matches per calibrated image.
9. Next, select the Project menu and choose “GCP/MTP Manager”. Import the GCP file provided for this survey. Change the horizontal accuracy of the GCPs to 0.02 m and the vertical accuracy to 0.05 m.
    a. Click on the “Basic Editor…” button. Assign a mark to 3 photos for each GCP. The photos will be preferentially sorted based on proximity to the provided GCP location. Match the crosshairs of your cursor to the crosshairs of that GCP in the image. GCP 467 is closer to the water, GCP 468 is next to the seawall. Select OK when finished assigning three ties for each GCP.

10. Open the “Process” menu and choose “Reoptimize”.
11. In the rayCloud view, expand GCPs / MTPs and the display properties. Highlight a GCP, and on the right side of the screen a properties window should appear that displays all the images that contain the selected GCP. Quickly mark all of the images, or choose auto identify, and click apply. Do this for each GCP and reoptimize.
12. Return to the “GCP/MTP Manager” and import the check point file provided. Highlight all of the rows containing these newly imported check points in the “GCP/MTP Manager” and right click on a cell that identifies it as a “3D GCP”, choose to edit types in selected rows, and assigne them to be “Check Point”. Select OK.
13. Navigate to the rayCloud menu and assign a mark to these checkpoints on three images. Use the position recommended by the software, which should show up as a blue dot within a larger blue circle. Identifying the position in three images should facilitate a computed position for the point. Ideally this spot would be unequivocally marked in the images. Since we do not have marks for these checkpoints, the horizontal errors that will be estimated are not valid. The vertical errors will be representative of the error in the dataset and will show up in the quality report produced after reoptimizing the dataset.

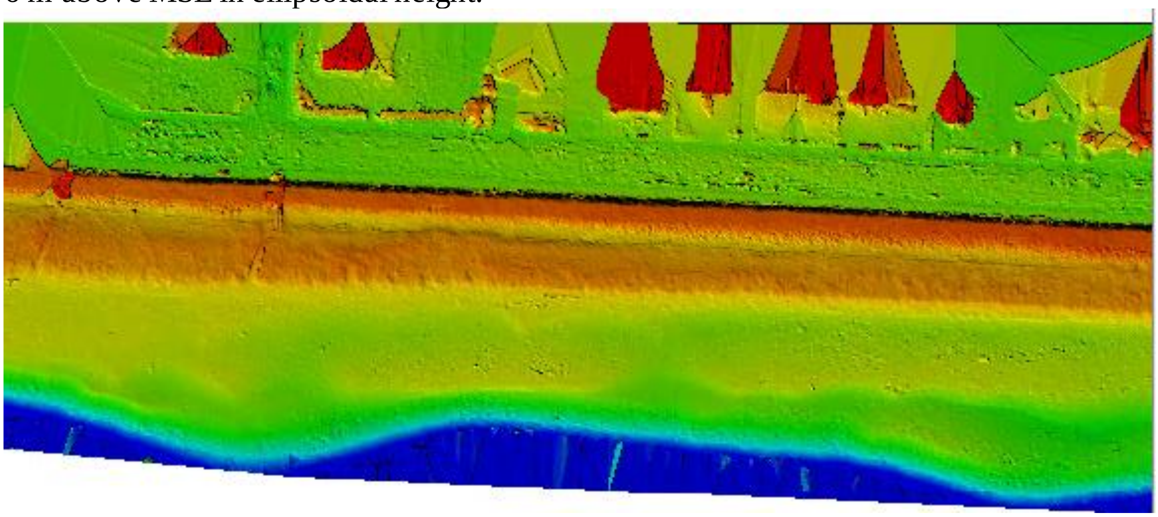


14. Open the process menu again and choose to generate another quality report.
    a. Note the Average Ground Sampling Distance (GSD).
    b. Note the RMS error and the projection error of the GCPs.
    c. Note the vertical RMS error of the checkpoints. Note the largest absolute vertical error of any checkpoint.
    d. Note the RMS error for the “Absolute Geolocation Variance” of the camera positions. Calculate the estimate of horizontal error hRMS = sqrt(xRMS^2 + yRMS^2).
15. Return to the processing options (bottom left), and highlight “2. Point Cloud and Mesh” and click the checkbox to apply that processing step. Uncheck the box that applies “1.

Initial Processing". Also click the checkbox to apply "3. DSM, Orthomosaic, and Index". In the options for the point cloud and mesh:

   a. For the "Image Scale", choose 1 (Original image size, Slow)
   b. For the "Point Density", choose "Optimal"
   c. Under Export, choose XYZ and delimiter "Comma", Merge tiles into one file.
   d. Select OK and start processing. This should take ~50 minutes.

16. Take a minute to view the dense point cloud, the mosaic orthophoto, and the DSM. Change the range of values in the DSM to -32.5 to -26 m. This is approximately MSL to 6 m above MSL in ellipsoidal height.



17. Note the differences in approach to measurement between the two exercises. In the first exercise, the camera position was not recorded but very accurate GCPs that surrounded the objects of interest were provided to the model. In the second exercise, the position of the camera was well-constrained but only two GCPs were provided that were located in the middle of the survey area. How might accuracy of measurement be affected if only one or two of the GCPs were provided to the first model, or the measurement of the camera positions was less accurate in the second?