ENV-408 EX05: Image Orientation, Orthophoto and Digitial Elevation Model Creation

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Objectives

1. Gain experience using a professional photogrammetric software suite to apply the concepts learned in labs 1 - 4 in practice.
2. Understand the processing steps necessary to go from raw imagery to an orthomosaic photo and digital terrain model.
3. Understand how the settings and information considered during the processing impacts the adjustment steps and ultimate quality of the data products.

Methodology

- Perform *Structure from Motion* (Detection & Matching, Aerial Triangulation and Optimization) on a set of images followed by dense-matching.
- Use the obtained 3D point cloud to *create a Digital Elevation Model* **(DEM)**.
- Create an *ortho-mosaic* image with DEM and oriented and calibrated photos.
- Learn how to prepare the products to be visualized and exported for further use.

Inputs

- Images: A set of (**47**) overlapping images taken from an aircraft over our study area.
- Exterior orientation file: Contains the position and attitude (Pose/EO) of each image derived from navigation sensor (GPS/INS) in *East*,*North*,*Up*, *Omega*,*Phi*,*Kappa* along with the associated accuracy measures (standard deviations, 1σ).

Outputs

- 3D *point-cloud*, Digital Terrain Model (*DTM*), and *Ortho-mosaic* photo.

  NOTE: The DTM of this lab will be used in the following lab in this course (Lab06)!

Task 1

- Following the detailed guide describing the workflow in `Agisoft Metashape` on [Moodle]: `Ex5_DEM_Orthomosaic_Agisoft_Guide.pdf`, you will be able to *correctly* produce the mapping outputs required for this task.
- The workflow described in the `Agisoft Guide`, produces a classified, dense matching point cloud, digital terrain model **(DTM)** and ortho-mosaic from the, of the image data set.
- The exercises to complete after **Task 1** are described in detail below.

EX1: Camera Calibration

- In this exercise you will evaluate how the camera calibration is affected by varying the *type* and *quality* of observations available for use in the optimization.
- The processing results for your image set will be duplicated assuming that only the camera *locations/positions* are known for each image with standard GPS position accuracy (5-10 meters, 1σ).
- The differences in the overall error observed in the aligned images and recovered camera will be evaluated as well as the the estimated camera calibration parameters by comparing a processing report produced by the software.

Procedure

- As in Section `1.3` of the `Agisoft guide`, create a new chunk by **right-clicking** in the `Workspace` area of your project and select *Add Chunk*.
- Give a name to this chunk for organizational purposes by **right-clicking** on the chunk and selecting *Rename*.
- Next, reload the same image group folder as was done in *1.4* of the `Agisoft-guide` into the new chunk.
- Now import the reference file again as was done in the initial processing (1.5 Agisoft Guide), **right-click** on the new image **`Chunk`**, select `Import->Import Reference ...`
- We will test processing the image set using only the location information associated with each photo and that with standard accuracy of several meters (default value). Navigate to the same reference file processed in Task 1, `R:\TOPO\SM4EO\EX05\POSES` directory, select the reference file `EX5_GPS_IMU_OPK_STD.TXT`.
- When importing the reference file, configure the following settings as shown in **Fig. 1** below:

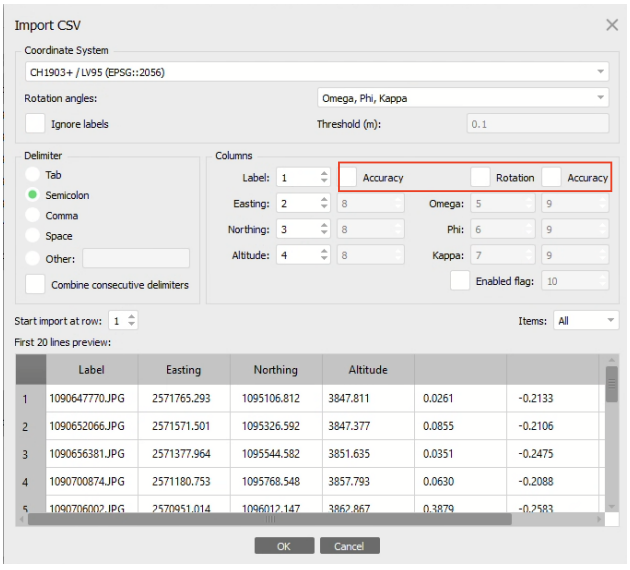

Figure 1: **Fig. 1: Import Reference Settings - No Attitude/Accuracy**

Note 1: Ensure that the `Accuracy` and `Rotation` boxes in the `Columns` section are **unselected** for this step (Fig. 1).

Note 2: After loading the reference file using only the image coordinates, you'll see by looking at the *reference* tab that the default `Accuracy` of the position is 10 m.

Note 3: We will not be loading the camera calibration or offset information for this chunk, as we are trying to simulate a case in which this information is unknown.

- Run the Aerial triangulation step on the new chunk, `Workflow -> Align Photos`.
- On the pop-up window that appears, apply the settings as detailed in the `EX5_Agisoft_Guide (Tab / Fig. 9)`.
- Next generate a dense matching point cloud for the new image chunk. Go to the `Workflow` tab, and select `Build Point Cloud ....` On the pop-up window that appears, apply the same settings as detailed in the `Agisoft guide` **Task 3**.
- From the derived dense point cloud we will generate a new DEM, *this time without applying point cloud classification*. Go to the `Workflow` tab, and select `Build DEM`. Apply the settings as shown in **Task 5** of the `EX05_Agisoft_Guide`, this time leaving '`Point Classes` unselected.

Analysis

- We will now compare the processing results of your image set for each processing configuration applied together with the associated processing reports.
- To generate a processing report for your first (better calibrated) and second (less-calibrated) results go to *File->Export->Generate Report*
- The processing report for the reference data can be viewed in the data drive:

  `R:\TOPO\SM4EO\EX05\Reference\EX_Ref_Processing_Report.pdf`

Questions

1. How the estimated camera locations changed after the bundle adjustement (i.e. optimization/calibration) with respect to the observed input (i.e. the loaded image orientation file)? What are the respective estimated accuracy on camera location for both processing job?
2. How do the estimated camera constant (focal length) and principle point (page 3 of the report) compare for each processing? Which ones make more sense and why?
3. How do the image residual plots compare?
4. Which one of your processed results are closer to the reference and why?

Ex2: DEM differencing

- For this analysis we will use the reference DTM that has been pre-imported into the project template that was used to start this exercise.
- The `Reference Chunk` contains a DTM (`EX5_Full_DTM`) that was generated using a high precision dense point cloud using the full dataset.

Steps

- Follow the steps completed in Task 1 above for the full data set up to the point of building the DEM. > Note: As a reminder you should create a new chunk for this processing job and add the full data folder to it : `R:\TOPO\SM4EO\Ex05\IMAGES\IMAGES_All`
- When building the DEM, configure the *Source data* to use the Depth maps instead of the Dense cloud. This will allow you to lower the resolution of DEM to **one meter** as shown in **Fig. 3** below. The one meter resolution DTM will be used as input for lab 6 in the following week.

Analysis

- We will now compare the processing results of your result from Task 1 to that of Task 2 (lo-resolution result) as well as to that of the provided reference processing report.
- To generate a processing report for your calibrated and non-calibrated results go to *File->Export->Generate Report*

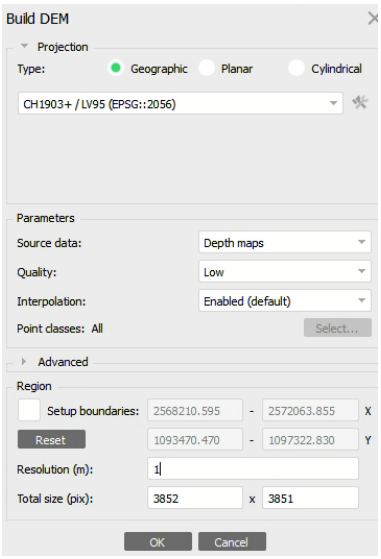

Figure 2: Building DEM with a lower resolution

- The processing report for the reference data can be viewed in the data drive:

  `R:\TOPO\SM4EO\EX05\Reference\EX_Ref_Processing_Report.pdf`

Questions

1. How does the reprojection error reported on the processing reports (Survey Data->Reprojection error) compare between the three processed data products? Do the relative values make sense?
2. Compare the calibration coefficients reported in Table 2. of each report. How do the adjusted values compare? Which values are closer to the initial values loaded from the `Cam_calib.xml` in Task 1?
3. Compare the dense clouds visualized by confidence for the results of Task 2 and that of the reference (*Reference Chunk -> EX5_full_dense_cloud*) processing jobs. Which one is more precise and why?