

ENV-408 EX05: Image Orientation, Orthophoto and Digital 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 Bundle Adjustment 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.

Overview

- The following exercise will first guide you through a general data processing workflow to produce a digital terrain model, dense matching point cloud, and ortho-mosaic from aerial photos.
- A detailed guide which describes the steps and operations in Agisoft Metashape to conduct this workflow is included as a separate document for this exercise on [Moodle](#): Ex5_DEM_Orthomosaic_Agisoft_Guide.pdf. The basic steps are summarized as follows:

Agisoft Metashape Project

```
|-- Start Agisoft/Mount Drives
|   Save Agisoft Project to results drive
|   Load Image Folder into Project
|   Load Image Reference Location/Image Poses
|
|-- Aerial-Triangulation of Images
|   -- key point detection/matching
|       -- key point filtering
|           -- relative orientation
|               -- optimization
|-- Build DEM
|   -- Dense image matching
|       -- Triangulate point-cloud generation
|           -- 3D Vertex/Triangulated irregular network model
|               generation.
```

```
|
| Build Orthomosaic
|   -- Orthorectification of images projected onto information.
|
| -- Crop DEM/Orthophoto to border for product export.
|
| -- Export DEM and Orthomosaic
|   -- Export in Swiss and WGS-84 coordinates and formats to
|       visualize products on other platforms (GIS/Google
|       Earth).
```

- You will then perform some comparative analysis of your produced data products in one of three exercises.

Input and Output Data

Input

- Aerial Images: A set of overlapping images taken from an aircraft over our study area.
 - A set of (47) images will be processed as one of the exercises for this lab to produce the outputs used later in the course.
- Image orientation file: Contains the position and attitude (camera Pose/EO) in *East, North, Up, Omega, Phi, Kappa* along with the associated accuracy measures for each image used in the aerial-triangulation process.

Output

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

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, **47** image data set.
- The exercises to complete after **Task 1** are described in detail below.

Exercise Overview

- The following exercises are designed to evaluate the results of the processing workflow that was accomplished in **Task 1** by comparing them to processing results with less assumed knowledge of the camera calibration and pose.

EX1: Camera Calibration Parameter Adjustment

- In this exercise you will evaluate how the camera calibration is affected by varying the number of observations available for use in the optimization.
- The processing results for your image set will be duplicated assuming that only the camera locations are known for each image with standard GPS position accuracy (several meters).
- The differences in the overall error observed in the aligned images will be evaluated as well as the adjustments made to the estimated camera calibration parameters by comparing a processing report produced in Agisoft.

Procedure and Analysis

- For the exercise assigned to your image group, complete the following steps to perform the requested analysis.

Ex1 and Ex2

Steps

- 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:\TOP0\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:

	Label	Easting	Northing	Altitude		
1	1090647770.JPG	2571765.293	1095106.812	3847.811	0.0261	-0.2133
2	1090652066.JPG	2571571.501	1095326.592	3847.377	0.0855	-0.2106
3	1090656381.JPG	2571377.964	1095544.582	3851.635	0.0351	-0.2475
4	1090700874.JPG	2571180.753	1095768.548	3857.793	0.0630	-0.2088
5	1090706002.JPG	2570951.014	1096012.147	3862.867	0.3879	-0.2583

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

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

Note: 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: 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

Ex1-Camera Calibration Parameter and Projection Error Comparison

- We will now compare the processing results of your image set for each processing configuration applied 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*
- The processing report for the reference data can be viewed in the data drive:

R:\TOP0\SM4E0\EX05\Reference\EX_Ref_Processing_Report.pdf

Questions

1. How the estimated camera locations changed after the bundle adjustment (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 focal length and principle points (page 3 of the report) adjusted for each processing job compare? 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?
- A new differenced DEM will be created for each of your processed Task 1 and 2 datasets for comparison.
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Ex 2 - Full Dataset Processing vs. Reference

- In this exercise compare your results to those of the provided reference data.

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:\TOP0\SM4E0\EX05\IMAGES\IMAGES_A11
- 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*
- The processing report for the reference data can be viewed in the data drive:

R:\TOP0\SM4E0\EX05\Reference\EX_Ref_Processing_Report.pdf

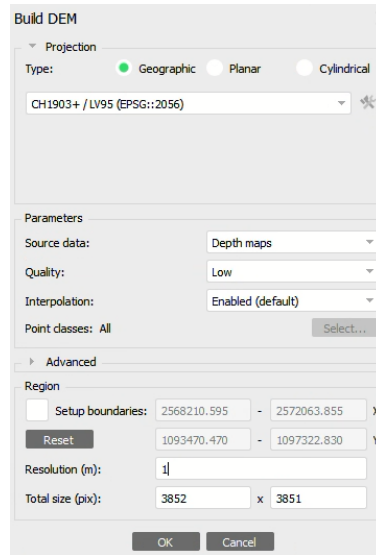


Figure 2: Building DEM with a lower resolution

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?