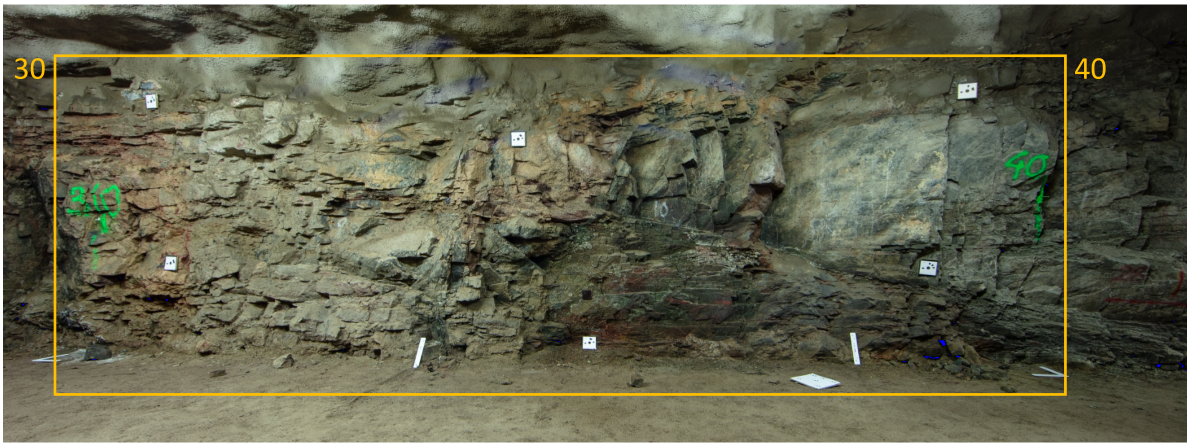
Tunnel 360 virtual tour/visit – Data Acquisition Workflow

The goal of this workflow is to familiarize you with the general steps of acquiring photos for the creation of 3D models and understanding the principles of photogrammetry. Conventional methods of rock mass characterization include mapping the discontinuities using traditional methods like geological compass. However, these methods come with their limitations. Remote rock mass characterization is an emerging means of rock mass mapping conveniently and with a minimal amount of human error. Photogrammetry is the art and science of extracting information from photos. It allows for an efficient and cheap method of recording surface geometry using cameras. For the photogrammetry process to work, the first step is data acquisition. It's vital to follow the proper steps of data acquisition to create good-quality models in the processing stage.

Objectives

1. Learn the basics of photography.
2. Learn the practical side of photogrammetry.
3. Learn the steps of photogrammetry.
4. Perform the steps of photogrammetry.



Equipment needed

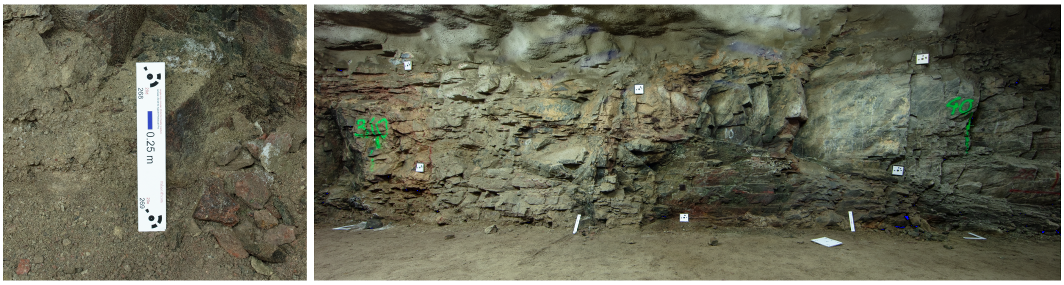
The following camera gear and mapping equipment needed for photogrammetry:

- DSLR camera with wide angle lens (e.g., 14 mm)
- Tripod
- 4 Scale bars and 1 alignment board
- Shutter release remote
- Geological compass
- Spare camera batteries
- Measuring tape

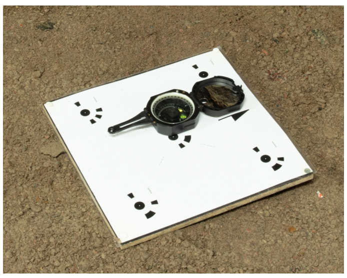
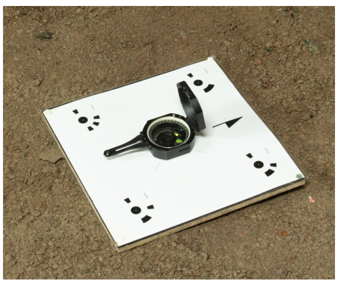
Below is a detailed step-by-step instruction on how to acquire photos for photogrammetry.

Instructions for T8 photogrammetry

1. Scaling and control distances. Distribute the 20-bit markers along the test section of tunnel 8. Place 2 scale bars horizontally on the ground and 2 vertically, leaning against the tunnel wall. Use the side that shows a bigger-sized pattern.



2. Orientation. Place the alignment board on the ground near the wall and align it to the true north using a geological compass. Place the compass on the board and rotate the board until the upwards-facing arrow is pointing in the same direction as the north needle of the compass (a). Then place the compass in the middle of the board and level the board by bringing the bullseye bubble of the compass in the middle (b). Finally, check again to see if the board is still aligned to the north.

a)  b) 

3. Targeted ground sampling distance. First, decide on the distance from the wall to the camera which will directly influence the ground sampling distance (GSD also called pixel size) of the 3D model (the size each pixel represents). In this exercise, we want to achieve a GSD of at least 1 mm. Next, use the online calculator [Photograph Field of View and Pixel Size Calculator – PhotoModeler] to calculate the distance required to achieve the set GSD. We will use Canon 5Ds R with a 14 mm wide angle lens (50 MP full-frame sensor with 36x24 mm size). Input the camera and lens specs and check what pixel size these parameters result in. Adjust the distance so that the pixel size is sufficient.
4. Image overlap. One of the main principles of photogrammetry is to have sufficient overlap between photos. Before taking the first photo, it's important to calculate the translation distance between every shooting point. Knowing the focal length of the lens and distance from the wall, the computed coverage width is calculated using the same calculator as in the previous step. For > 60% overlap, the translation distance is at least (1/3) of this coverage width. Using this value, go to the next shooting point (camera station).
5. Camera settings. Set the ISO to 100 and the aperture to f/8 or f/11 with evaluative metering mode. Use the camera in aperture priority mode (A) and image format to RAW+JPEG. Take a test photo and inspect. Check histogram.
6. Capturing image sequences from various angles. To provide sufficient coverage, several rounds of overlapping image sequences must be done, with each round having a specific camera tilt. Usually, three rounds are enough. So, in the first round, keep the camera parallel to the tunnel wall. Go to the starting point of the test section (marked location) and set up the tripod there at the respective distance from the tunnel wall. Elevate the tripod by adjusting its legs and attach the camera to the tripod plate. Take a photo at every translated distance. Make sure to check the quality of the photo and then proceed on to the next camera station. It's advisable to mark the station points. Take photos along the tunnel wall until the section is covered. After the first round, lower the tripod elevation and tilt the camera up. Do the same steps as mentioned before and take the photos from the same camera positions as marked before. (This is done if the distance from the wall is not changed, otherwise, the new translation distance must be calculated, and new stations need to be marked). After the second round, proceed to the final round. Increase the tripod elevation and tilt the camera down. Repeat the same steps as above. Good practice would be to note down the number of stations and the number of images taken.

7. Export. Export the images from the camera.

Instructions for Drifts Photogrammetry

The instruction for drifts is fairly similar to the tunnel wall, except for the requirement to use lights to illuminate the drift. Place the 360 lights on the ground or preferably on a tripod to light up the drift. Perform the same steps as mentioned before however since the drifts are relatively small, just keep sufficient overlap (>70%) between subsequent images and decide on the photo network around the drift.

It's good practice to take photos perpendicular to the drift wall and then move inside the drift and establish a semicircular network to take the images. The tripod elevation and camera tilt are also important here as we need to have sufficient coverage of the walls and roof of the drift.