Data Acquisition Exercise

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TERRA
Remote rock mass characterization

Aalto University
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Learning goals

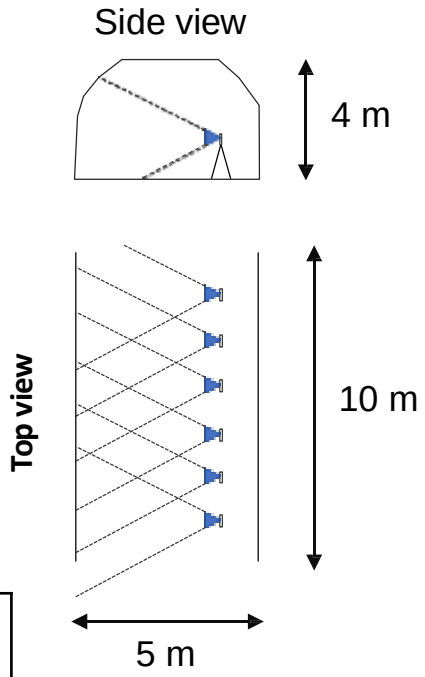
After this session you will be able to:

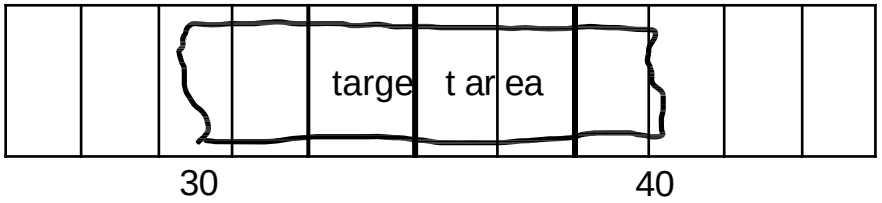
- Plan photogrammetric data acquisition
- Calculate ground sampling distance/pixel size

Exercise: design data acquisition plan for tunnel wall scan, chainage 30-40 (10 m long)

This is the data acquisition exercise. These slides will help in your ground based and Airborne assignment on Aalto OpenLearning.

1. Select equipment (camera+lens or drone or mobile phone)
2. Select settings such as aperture for your equipment
3. Calculate shooting distance and ground sampling distance GSD
4. Choose horizontal overlap and calculate images per row
5. Choose vertical overlap and calculate images per column
6. Draw a diagram on your shooting pattern, indicating camera positions and shooting directions





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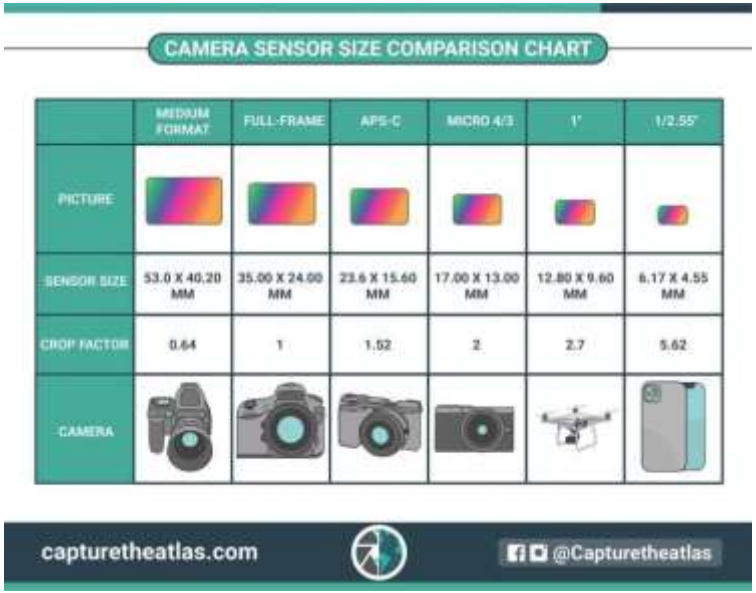
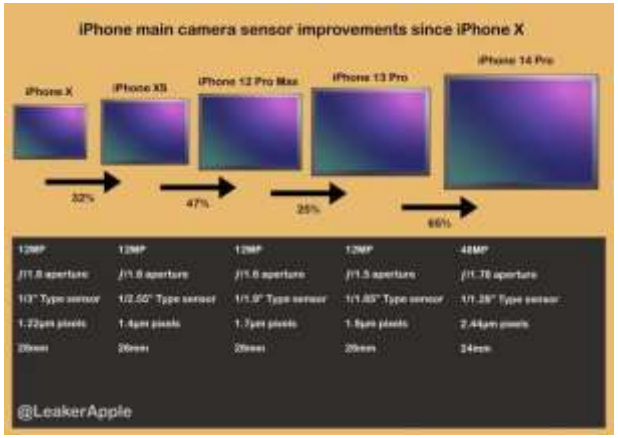
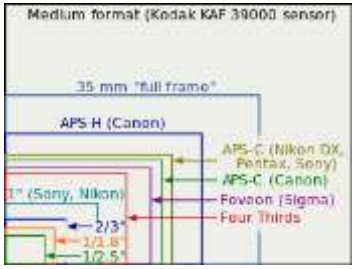
Camera

- most cameras work but use DSLR or mirrorless camera for best quality
- model resolution governed by pixel size/resolution
- good lens with low distortion => fixed focal length lens (prime)

Sensor size







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Canon 5DS R

- 50.6MP Full-Frame sensor
- 14mm lens: Canon EF 14mm f/2.8 L II USM
- 35mm lens: Canon EF 35mm f/1.4L II USM

Ground pixel size (= GSD)

Image credit: Kennrockwell

determine the approximate coverage (field of view) and the 'ground' pixel size of a particular lens and camera at a given distance

1. Input focal length

2. Input sensor format

5. Set a distance

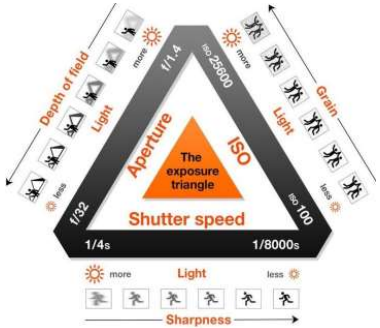
3. Set coverage to 80%

4. Input camera resolution

6. Check if the computed pixel size is less than required GSD and modify the distance if needed

https://www.photomodeler.com/pm-support/field-of-view-calculator/

Depth of field



https://www.dofmaster.com/dofjs.html

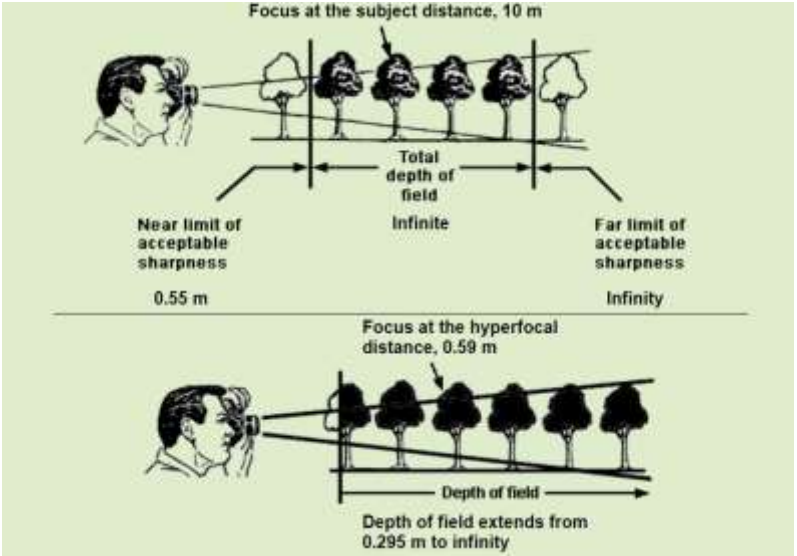
Camera, film format, or circle of confusion

Canon 5D (Mark II, Mark III)

Focal length (mm)	14	
Selected f-stop	f/11	
Subject distance	10	meters

Calculate

Subject distance	**10 m**
Depth of field	
Near limit	**0.55 m**
Far limit	**Infinity**
Total	**Infinite**
In front of subject	**9.5 m**
Behind subject	**Infinite**
Hyperfocal distance	**0.59 m**
Circle of confusion	**0.03 mm**



Required point density for discontinuity mapping

- Very high to high point density required
- A function of the minimum spacing between discontinuities
- Should be almost uniform
- Horizontal sets are more difficult to detect
- Rule of thumb: at least 8 points across the feature => min. detectable planar feature = 8*GSD

Task 1

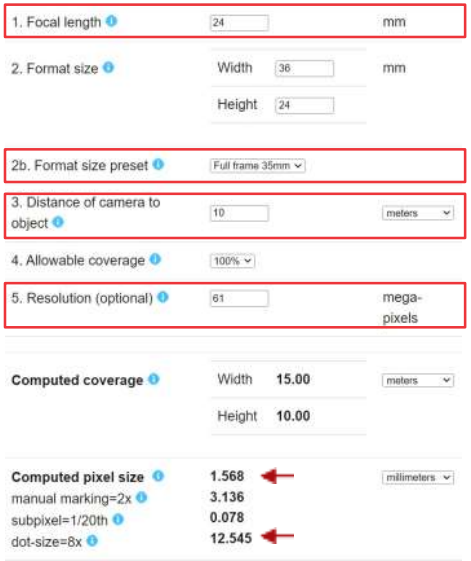
Calculate GSD (ground pixel size) and find the required shooting distance (or range of distances) for the following cases:

A. Canon 5DS R + 14 mm lens, tunnel face, required GSD = 1 mm

B. Canon 5DS R + 35 mm lens, tunnel face, required GSD = 1 mm

C. DJI Phantom 4 Pro V2 drone, open pit bench, min. joint spacing = 5 cm

D. DJI Phantom 4 Pro V2 drone, tunnel face, required GSD = 1 mm



Are the calculated distances realistic? What could be changed/improved?

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Data acquisition workflow for E02

Data Acquisition Workflow

Premise

The end goal of this workflow is to familiarize the students 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 up with their own limitations. Remote mass characterization is an emerging means of characterization rock mass features conveniently and with minimal amount of human error. Photogrammetry is the art and science of extracting information from photos. The same principle is applied here. It allows for efficient and cheap method of recording surface geometry using cameras. For 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.

This exercise is carried out in Tunnel 8 (T8) of the Underground Research Laboratory of Aalto University.

Equipment needed

The following camera gear and mapping equipment is needed for photogrammetry.

- DSLR camera with wide angle lens (preferably 14 mm)
- Tripod
- Scale bars and alignment board
- Shutter release remote
- Geological compass
- Spare camera batteries
- Measuring tape
- Helmet

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

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Targeted model resolution

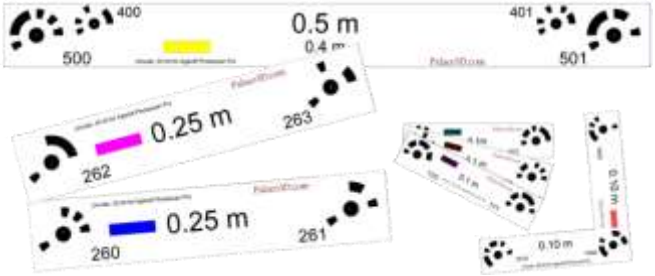
First, we decide on the distance from the tunnel wall to the camera which will directly
influence the resolution of the 3D model.

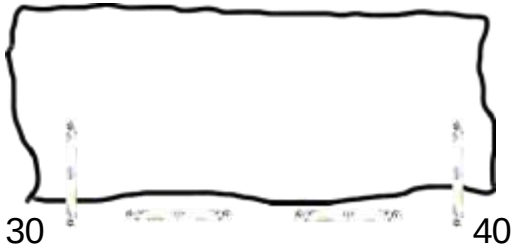
- achieve GSD of 1 mm or smaller
- use online calculator Photograph Field of View and Pixel Size Calculator – PhotoModeler to calculate the distance required to achieve the set resolution.
- we will use Canon 5DS R with a 14mm wide angle lens (50.6 MP full frame sensor with 36x24 mm size)
- Find a distance so that the calculated pixel size meets the requirements

Scaling and control distances

Distribute the 20-bit markers along the test section of the tunnel.

Place 2 scale bars horizontally on the ground and 2 vertically, leaning against the tunnel wall.





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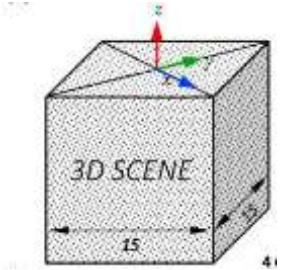
Orientation

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 same direction as the north needle of the compass.

Then place the compass in middle of the board and level the board by bringing the bullseye bubble of the compass in the middle. Finally check again to see if the board is still aligned to north.



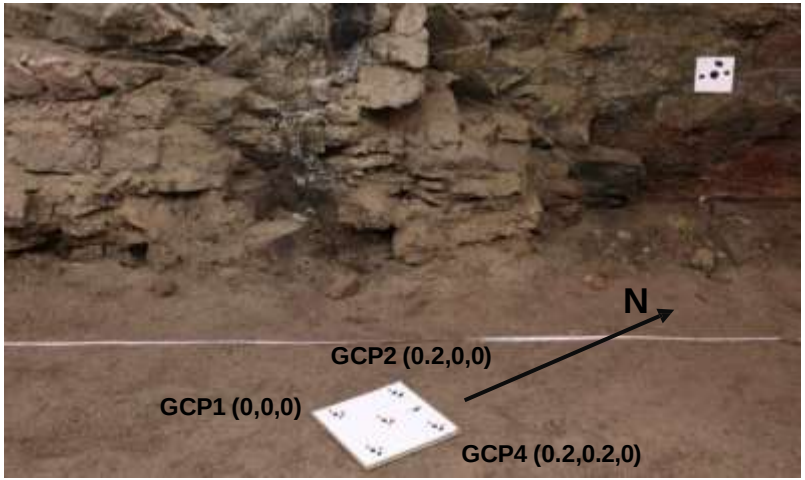
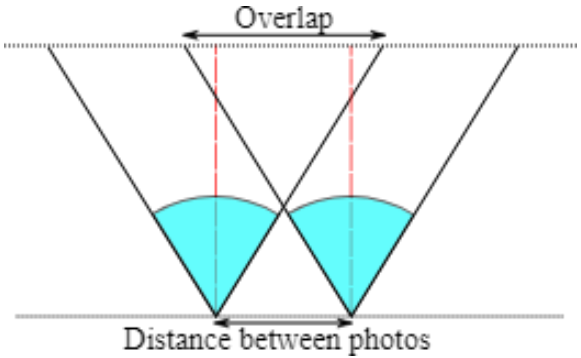


Image overlap

Use at least 60-70% overlap = 1/3 of computed coverage width



https://www.drewsilcock.co.uk/calculating-overlap

1. Focal length	24		mm
2. Format size	Width	36	mm
	Height	24	
2b. Format size preset	Full frame 35mm		
3. Distance of camera to object	10		meters
4. Allowable coverage	100%		
5. Resolution (optional)	61		mega-pixels
Computed coverage	Width	**15.00**	meters
	Height	**10.00**	
Computed pixel size	**1.568**		millimeters
manual marking=2x	**3.136**		
subpixel=1/20th	**0.078**		
dot-size=8x	**12.545**		

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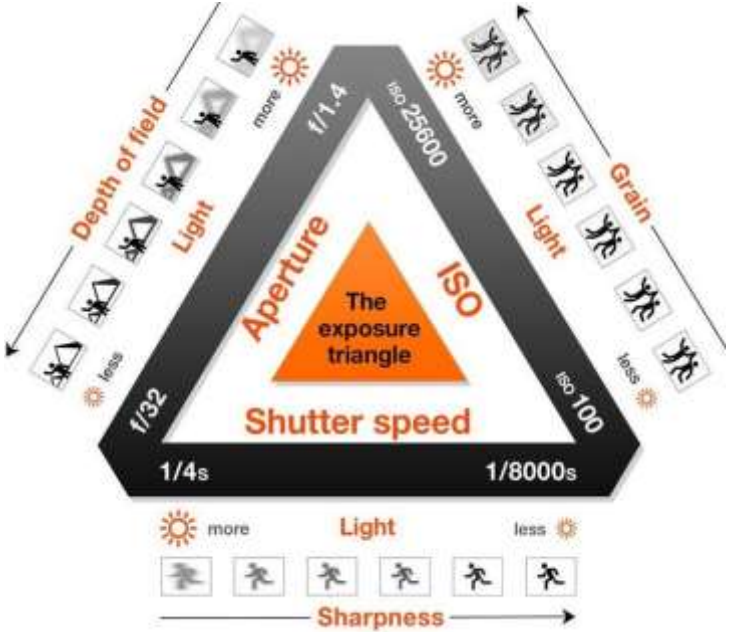
Camera settings

The default recommended settings aim to have the sharpest image possible:

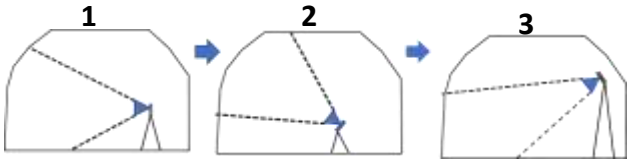
- Small aperture ≈ **f/8-f/11** for wide focal range
- **Low ISO** should be used to lower to avoid noise (grain)
- low lighting conditions: first increase the ISO, then the aperture
- set the output format to **RAW**
- Check histogram to avoid clipping in over/underexposed areas

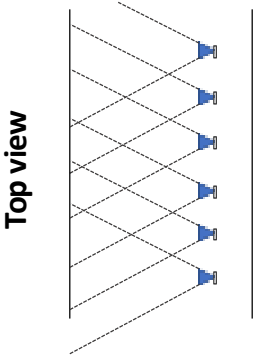


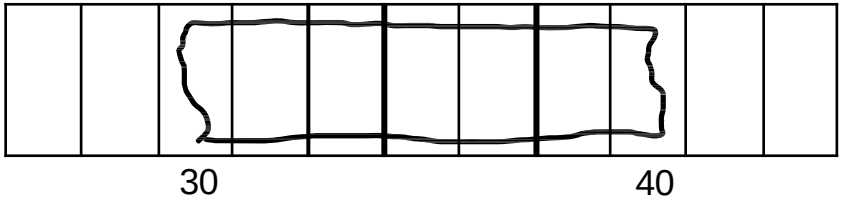
Source: petapixel.com

Capturing image sequence from various angles

- several rounds of overlapping image sequences to provide sufficient coverage
  - each point should be visible on at least 3 photos
  - few rounds with different height and camera tilt
  - usually, three rounds are enough
  - in the 1st round keep the camera parallel to the tunnel wall
- start so that 1/3 of the object is visible
- take a photo at every translated distance along the tunnel wall until the section is covered



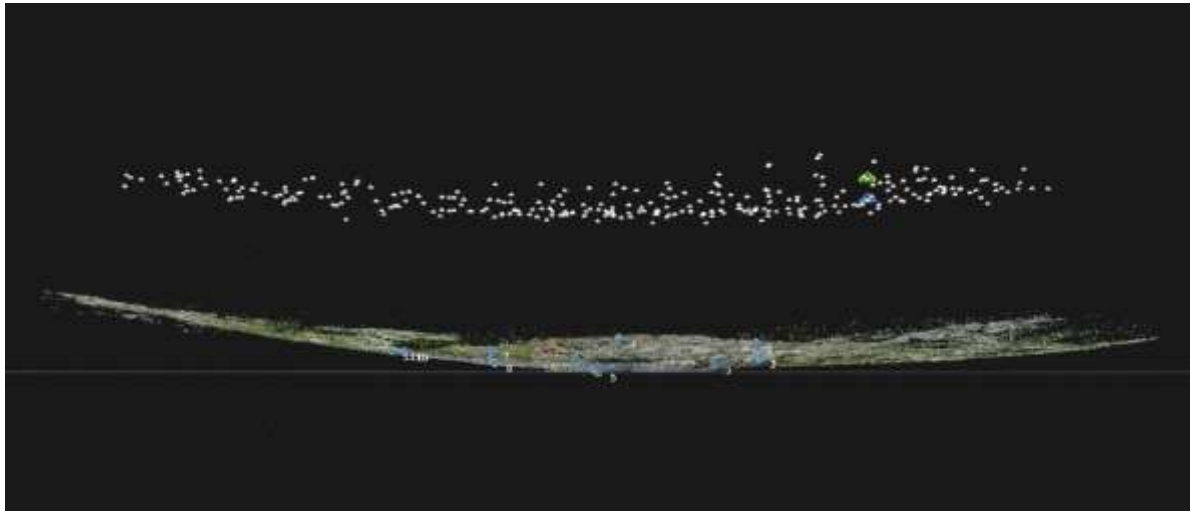




Common problems and remedies

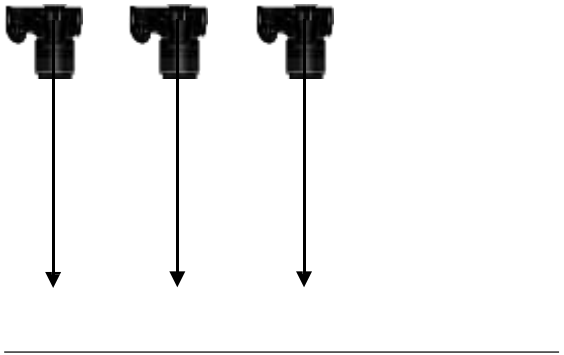
Problem: Curving (banana effect)

Curving can occur when the photos are taken in parallel to the surface to be reconstructed:

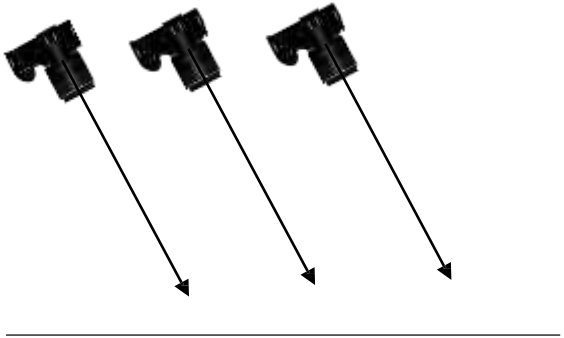


Angle cameras to eliminate curving

Do not (all parallel)

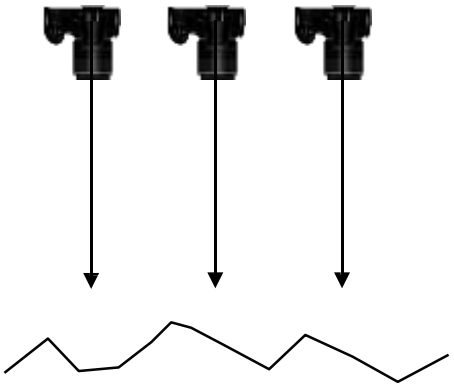


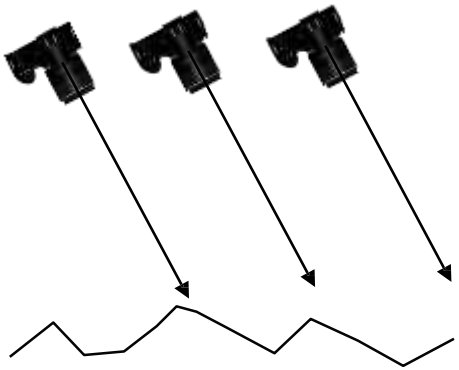
Do (angled)



Note: parallel works for jagged surfaces (and is the fastest and best texture quality)

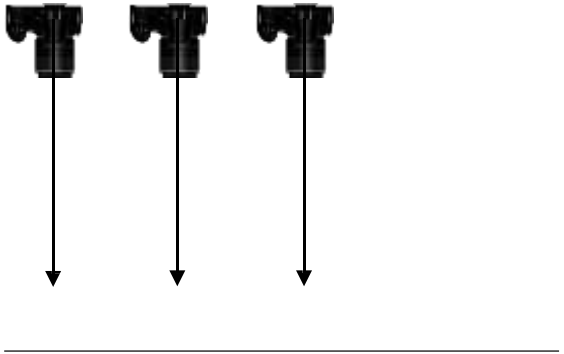
Do (all parallel) **or** **Do (angled)**

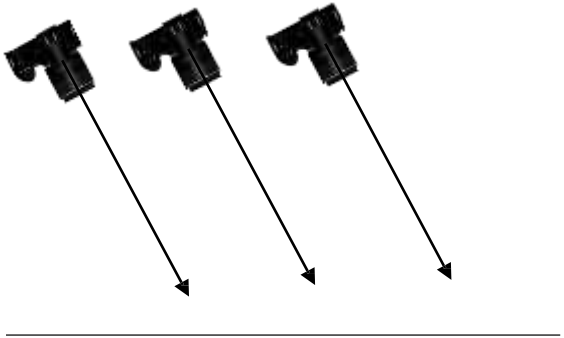




Optional: texture set for angled shoots

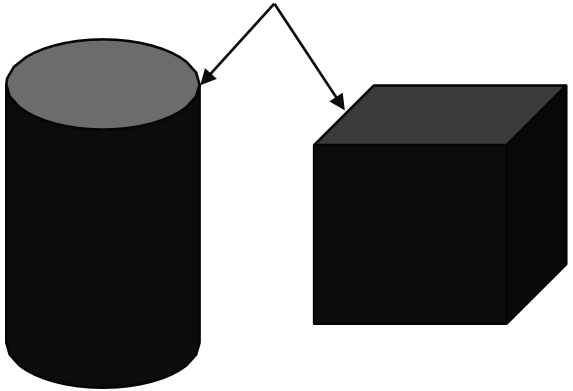
Parallel (texture weight = 100 %) **+** **Angled to avoid curving (weigh = 0 %)**





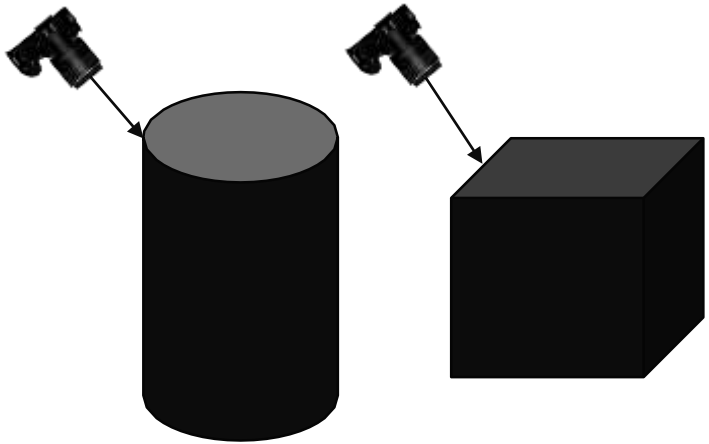
Problem: Multiple models

Multiple models are generated when there are not enough tie points between the parts. This can easily happen with sharp corners.



Add one round of photos to the corner

Focus the camera on the corner and ensure that approximately 50 % of each surface (top and side) can be seen. Usually this means 45 degree angle.



Problem: Background lock

In background lock, the background gets reconstructed and the revolving object in the center is either removed or becomes a poor 2nd model.

Solution: cover the background with textureless surface (paper, cardboard) or use masking:

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Problem: Motion blur

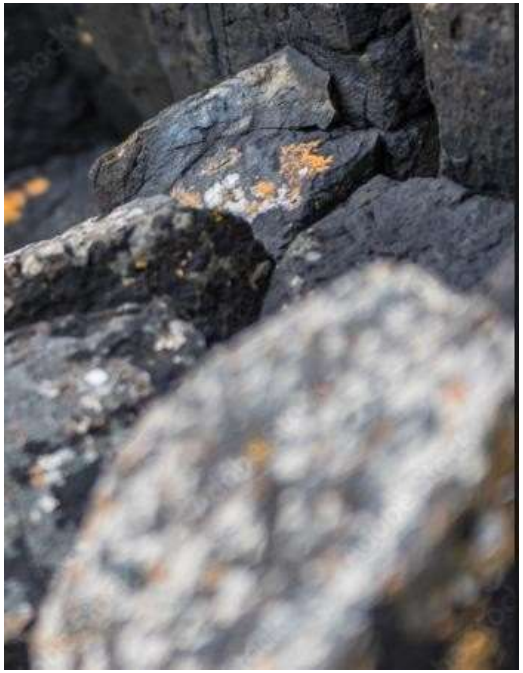
Solution:

- **More light**
- **More sensitive ISO (higher ISO number)**
- **Faster shutter speed, 1/500, 1/1000 or even faster**

OR

- **Tripod**
- **(Monopod helps, too)**

Problem: Out-of-focus



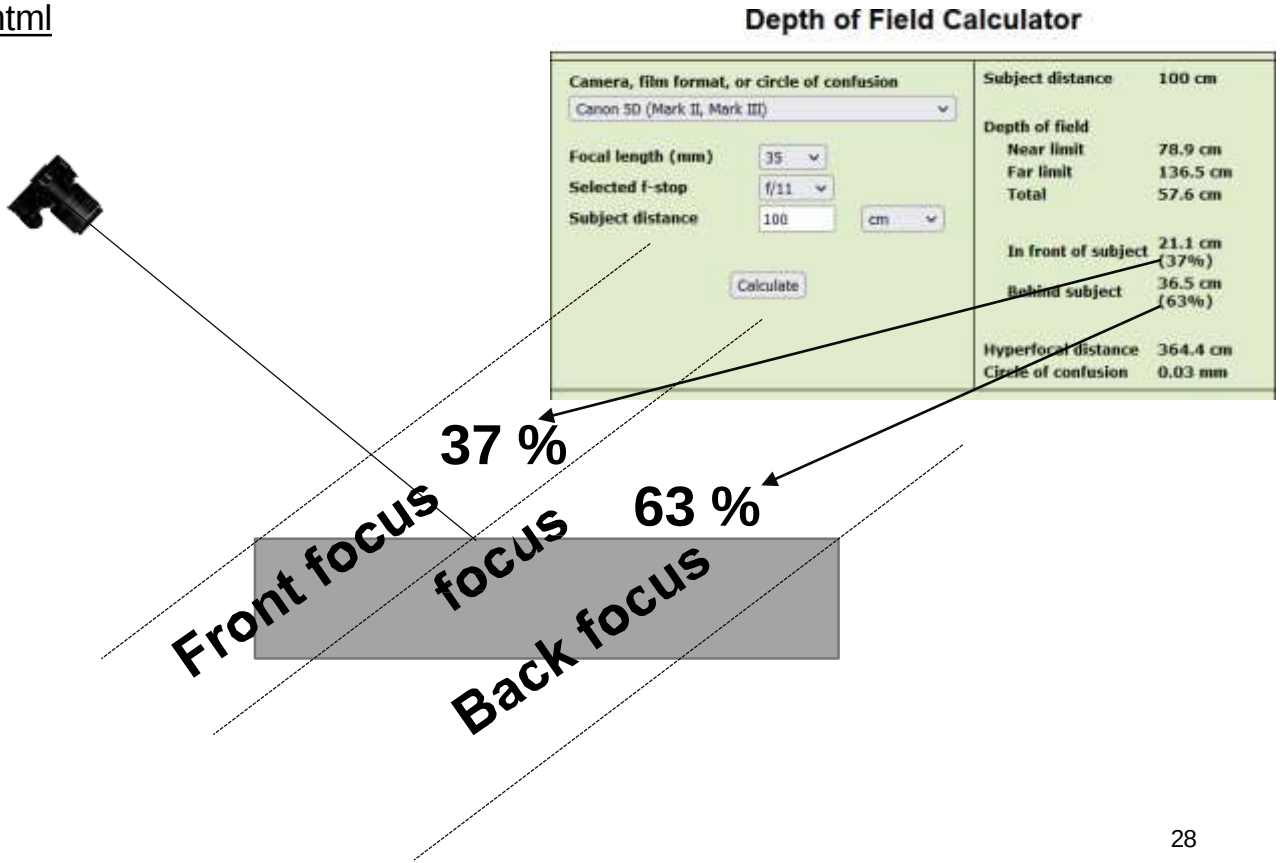
Solution:

- Smaller aperture (usually twice the maximum F stop is the sharpest, for example f/1.4 => f/2.8
- Usually this is not enough, and f/8 or f/11 gives best results. This results in small amount of diffraction.
- Best camera distance, focus point and front and back focus distances can be calculated using online calculators such as DOFMaster: https://www.dofmaster.com/dofjs.html

Example of focus values

Canon 5D + 35 mm lens
f/11, 100 cm distance

https://www.dofmaster.com/dofjs.html



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