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Accuracy assessment of a photogrammetric UAV block by using different software and adopting diverse processing strategies

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Focus

› Accuracy assessment of a photogrammetric block acquired by UAV

› Two main aspects:

1. The performance of different software
2. The influence of processing strategies

Outline

- Description of test-site
- Description of photogrammetric dataset
- Data processing and analysis
- Results
- Conclusions and further activities

Test-site

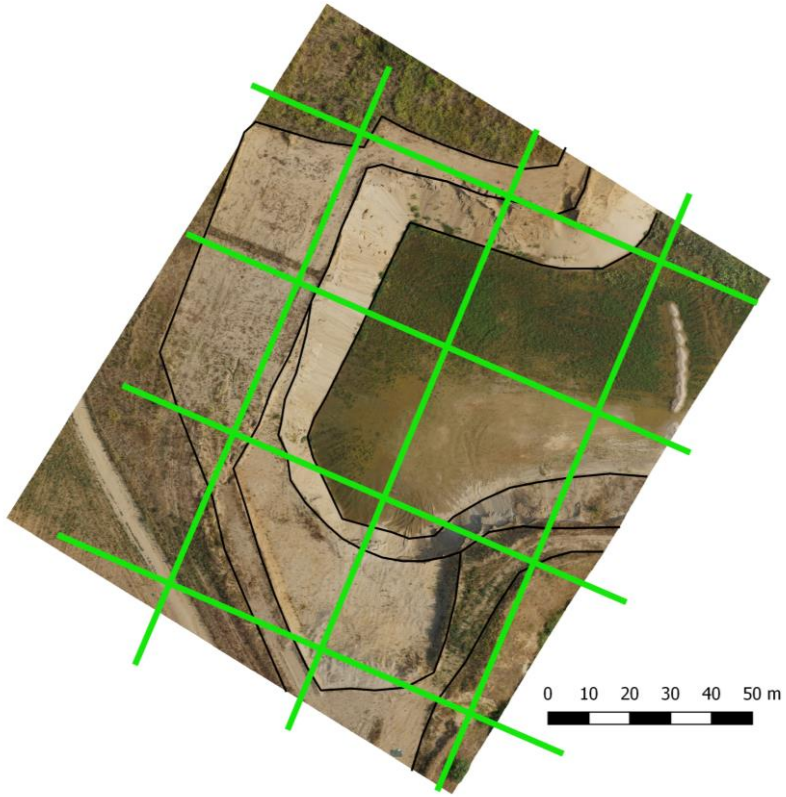
- A part of a large sandpit
- Two flat regions connected by the excavation front (10 m high)
- Slope between 30° and 90°
- 2 ha

Dataset

- Hexacopter having 1.5 kg of payload and 15 minutes of autonomy
- Sony A6000 camera (24 MP, 16mm focal length)
- 18 mm GSD at 70 m

- 18 artificial markers
- Integrated survey with total station and GNSS receiver
- 0.5 cm precision in planimetry
- 1 cm precision in altimetry

UAV blocks



End-lap: 77%

Side-lap: 60%

Block 1	North-South linear strips, 70 m, nadiral
Block 2	East-West linear strips, 70 m, nadiral
Block 3	Radial linear strips, 70 m, nadiral
Block 4	Radial linear strips, 70 m, 30° oblique
Block 5	Circular trajectory, 30 m, 45° oblique
Block 6	North-South linear strips, 40 m, nadiral
Block 7	East-West linear strips, 40 m, nadiral
Block 8	Radial linear strips, 40 m, nadiral

Data processing

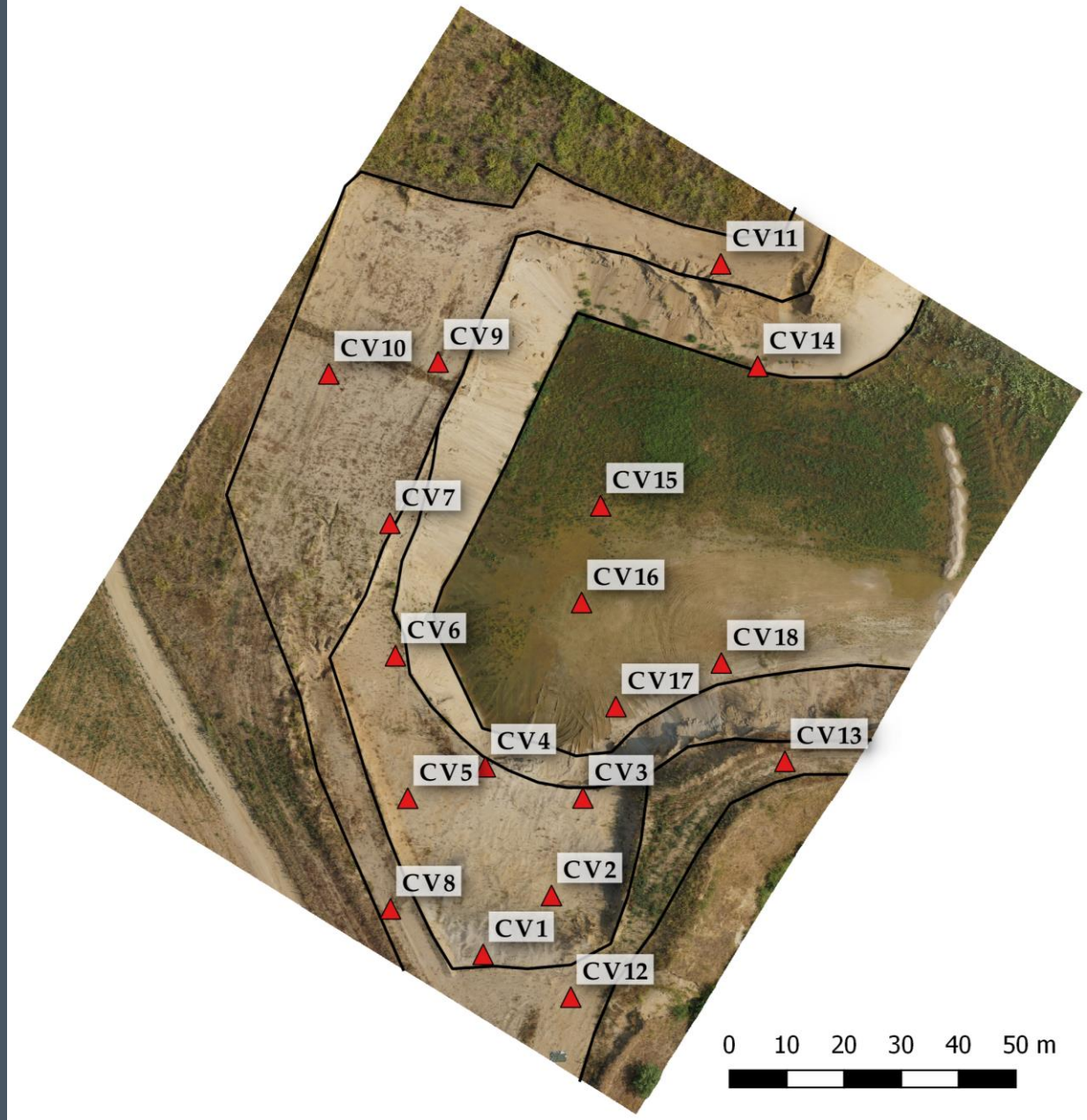
- The same dataset was processed by the two groups
- University of Pavia:
  - Agisoft Photoscan
  - Inpho UAS Master
- Polytechnic of Turin:
  - Pix4D
  - Bentley ContextCapture
  - MicMac

Data processing

- Number and distribution of GCPs/CPs were discussed in advance
- Three configurations were established:
  - 18 GCPs / 0 CPs
  - 11 GCPs / 7 CPs
  - 6 GCPs / 12 CPs

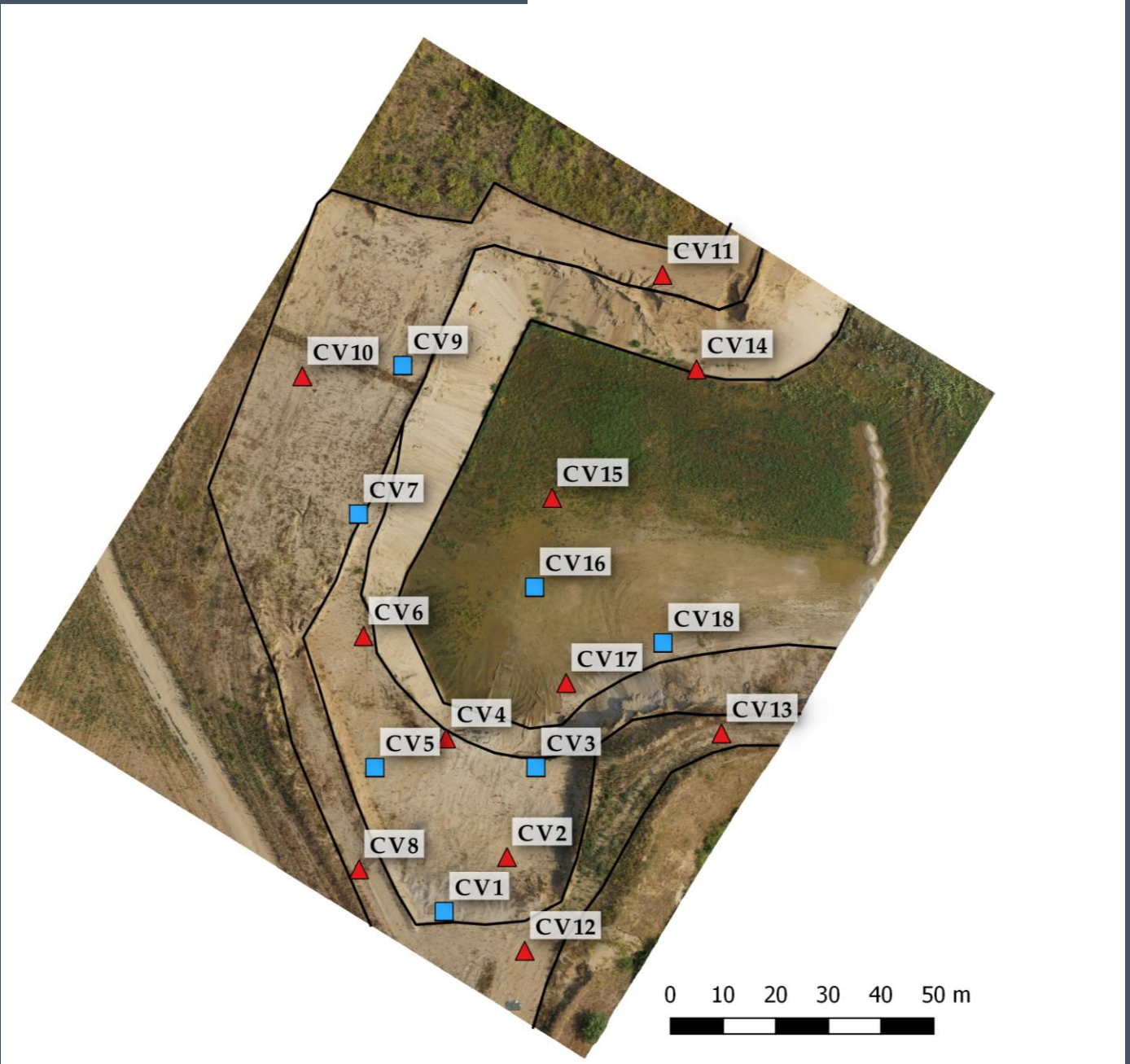
Configuration 1

- 18 GCPs / 0 CPs
- all the markers are used as GCPs, to perform robust camera calibration



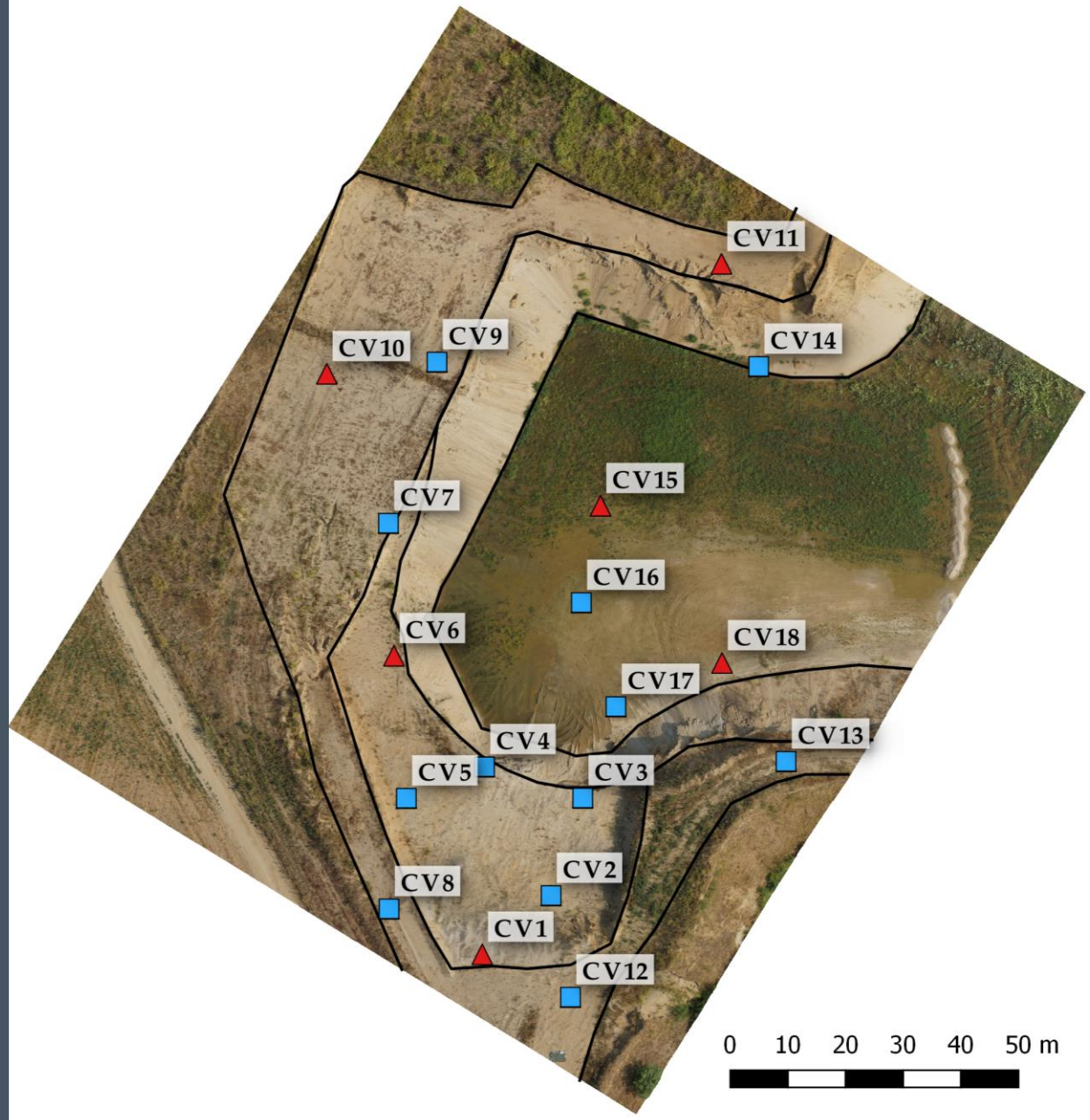
Configuration 2

- 11 GCPs / 7 CPs
- intermediate setup with strong ground control and still some check points



Configuration 3

- 6 GCPs / 12 CPs
- only 6 points are used as GCPs, that is realistic for routine surveying



Processing and analysis

- The photogrammetric processing were managed independently by the two groups:
  - image alignment
  - camera calibration
  - adjustment weighting
- Residuals between the photogrammetrically-obtained object-coordinates of markers and those determined by surveying were formed and compared

Some common points

- Extraction of tie points on high resolution images (Photoscan, UAS Master, Pix4D, Context Capture)
- Markers were measured independently but using a conservative strategy: average number of measurements per marker between 15 and 18 (exception 26 for Pix4D)
- GCPs weight set to:
  - 0.5 cm for planimetry
  - 1 cm for altimetry

Agisoft Photoscan

- Image coordinates weights set 0.25 pixel for GCPs and 1.5 for tie points
- Interior camera parameters optimization set to default

Photoscan		GCP			CP		
		X [m]	Y [m]	Z [m]	X [m]	Y [m]	Z [m]
Config 1	rmse	0.003	0.003	0.009	-	-	-
Config 2	rmse	0.003	0.003	0.009	0.004	0.005	0.013
Config 3	rmse	0.001	0.004	0.006	0.004	0.006	0.017

Inpho UAS Master

- Needs approximate external orientations
- Doesn't allow to set weight for image coordinates

UAS Master		GCP			CP		
		X [m]	Y [m]	Z [m]	X [m]	Y [m]	Z [m]
Config 1	rmse	0.003	0.002	0.008	-	-	-
Config 2	rmse	0.003	0.003	0.008	0.007	0.004	0.020
Config 3	rmse	0.007	0.005	0.015	0.005	0.004	0.024

Pix4D

› Less flexible in which interior parameter optimize

› Doesn’t allow to set weight for image coordinates

Pix4D		GCP			CP		
		X [m]	Y [m]	Z [m]	X [m]	Y [m]	Z [m]
Config 1	rmse	0.004	0.005	0.010	-	-	-
Config 2	rmse	0.004	0.005	0.008	0.005	0.007	0.015
Config 3	rmse	0.004	0.008	0.008	0.005	0.005	0.014

Bentley ContextCapture

› Less flexible in which interior parameter optimize

› Doesn’t allow to set weight for image coordinates

ContextCapture		GCP			CP		
		X [m]	Y [m]	Z [m]	X [m]	Y [m]	Z [m]
Config 1	rmse	0.004	0.004	0.009	-	-	-
Config 2	rmse	0.005	0.004	0.009	0.009	0.007	0.012
Config 3	rmse	0.008	0.005	0.029	0.011	0.007	0.042

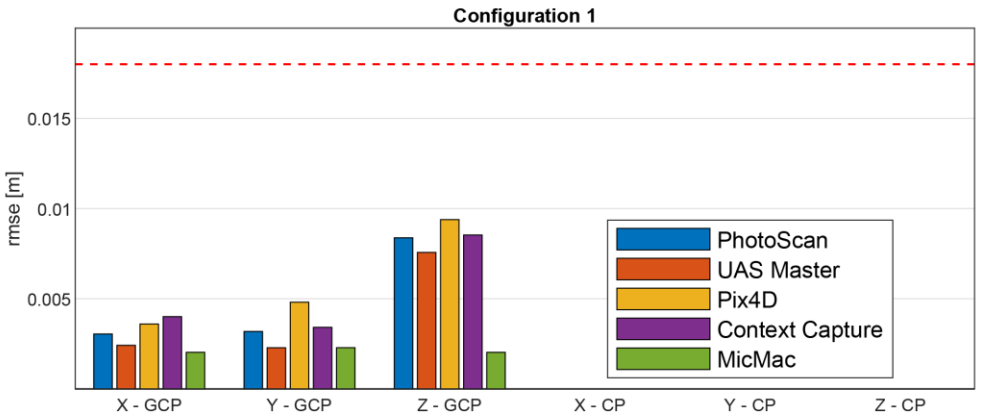
MicMac

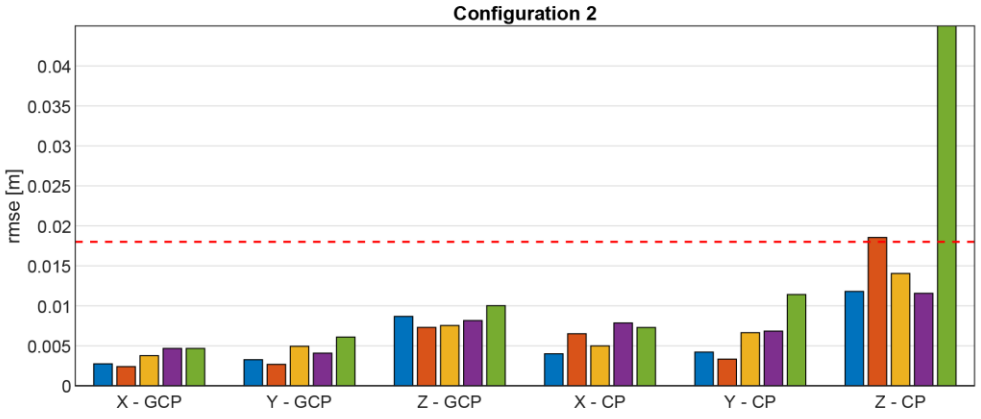
- Images were resampled at 1500 pixels
- Fraser camera model
- GCPs weight set to 1 cm for planimetry and altimetry
- Manually measured image coordinates weight set to 0.5 pixel

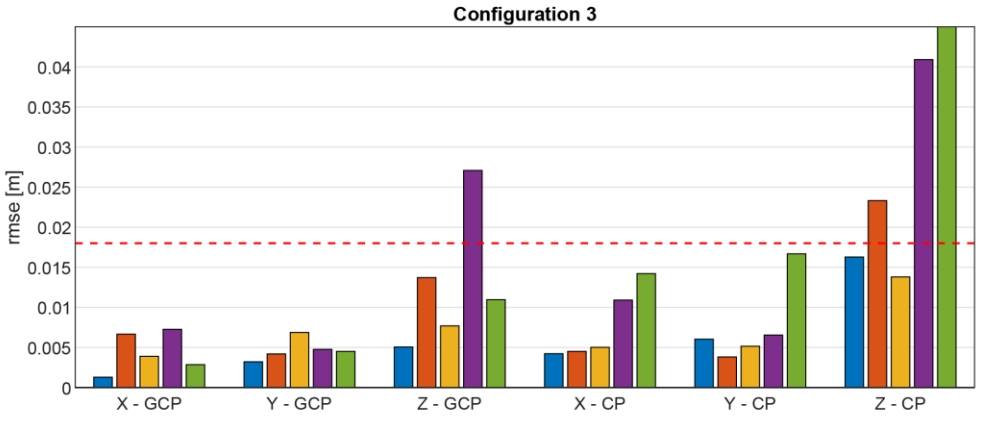
MicMac		GCP			CP		
		X [m]	Y [m]	Z [m]	X [m]	Y [m]	Z [m]
Config 1	rmse	0.002	0.002	0.002	-	-	-
Config 2	rmse	0.005	0.006	0.011	0.008	0.012	0.096
Config 3	rmse	0.003	0.005	0.012	0.015	0.017	0.106

Results 1

- Horizontal components always perform better than Z
- Only exception is MicMac in Configuration 1

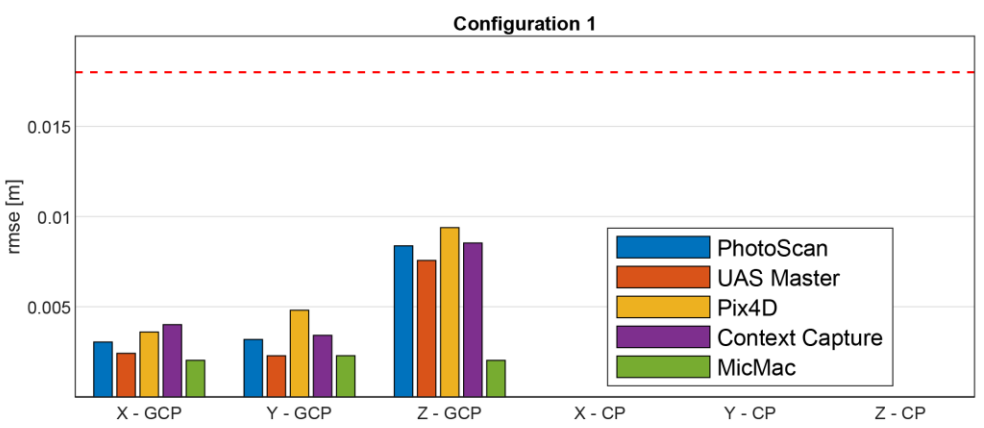


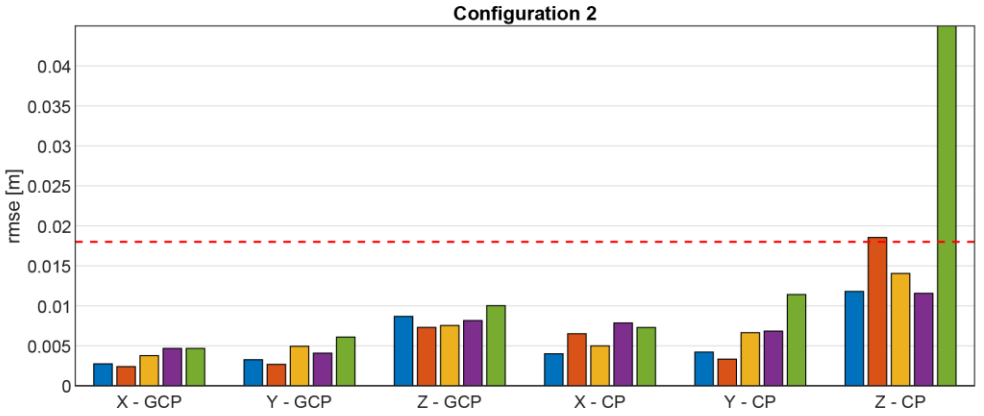


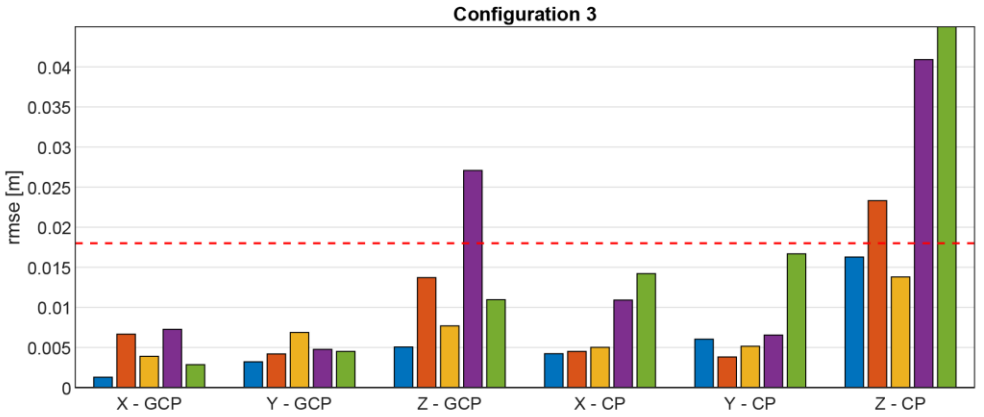


Results 2

- BBA estimates exterior orientation parameters in order to reach best fitting between photogrammetric and topographic GCPs coordinates
- Accuracy figures for GCPs underestimate actual ones
- Differences between GCPs and CPs results are less evident than expected

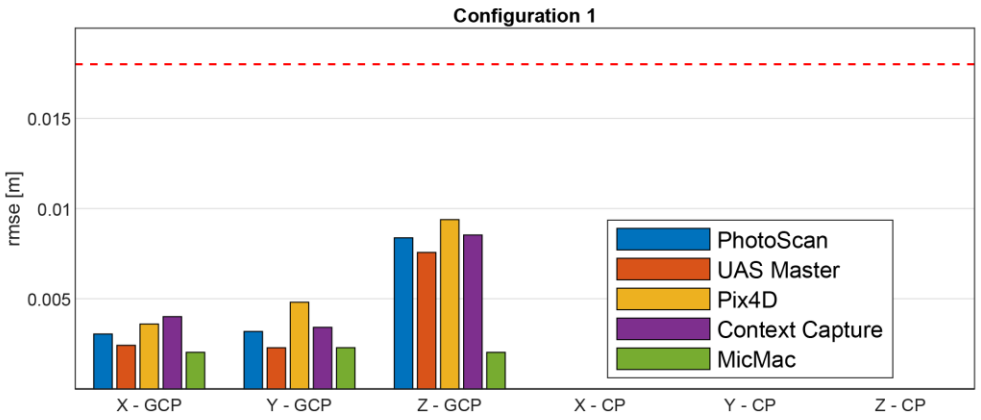


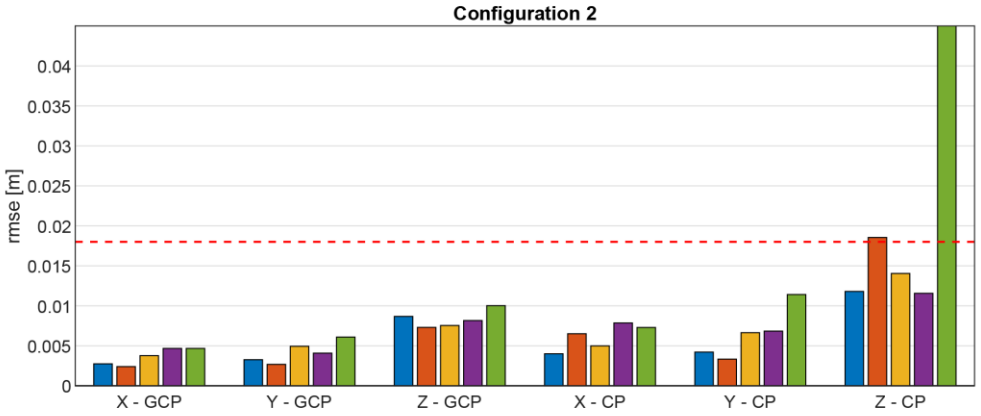


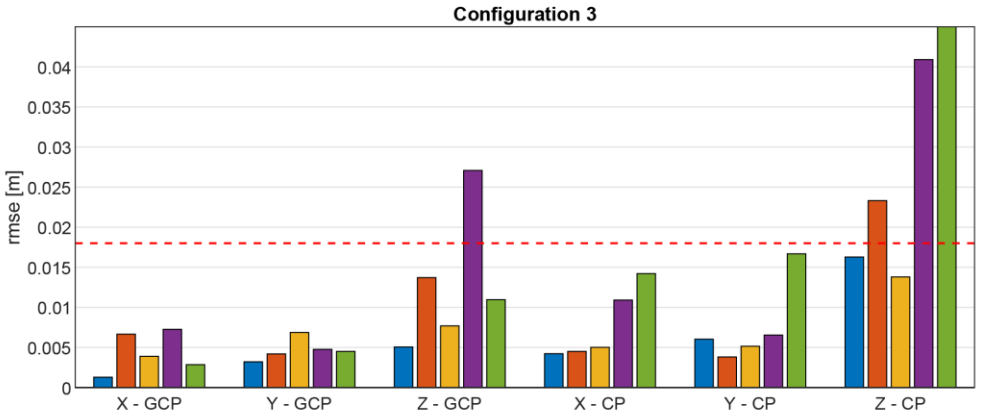


Results 3

- Number of GCPs influences the results that in general remain good
- ContextCapture has a significant degradation passing from Config 2 to 3 in Z component
- MicMac has large problem in altimetry probably connected to camera model

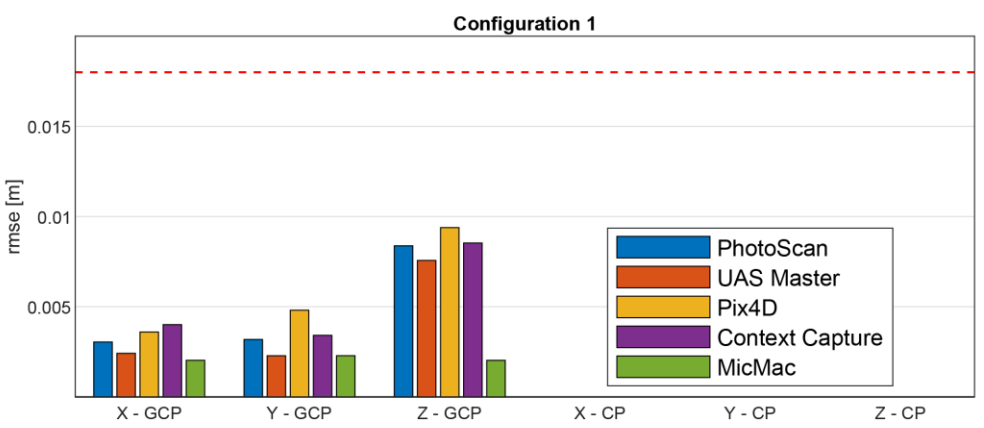


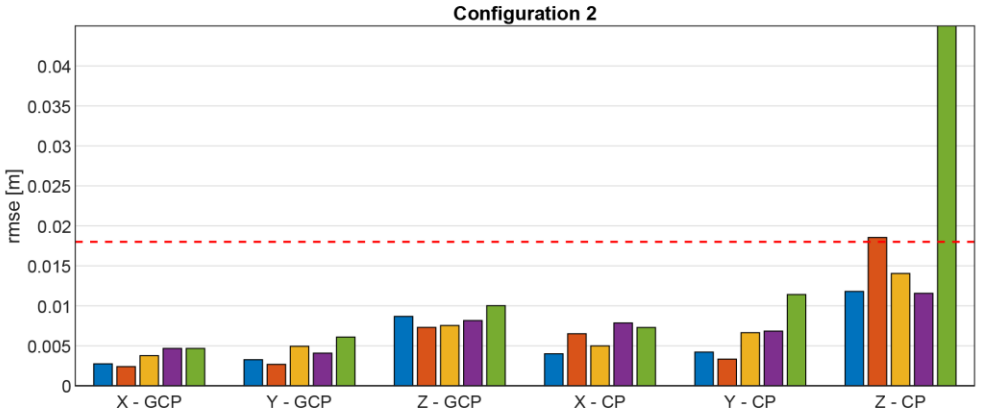


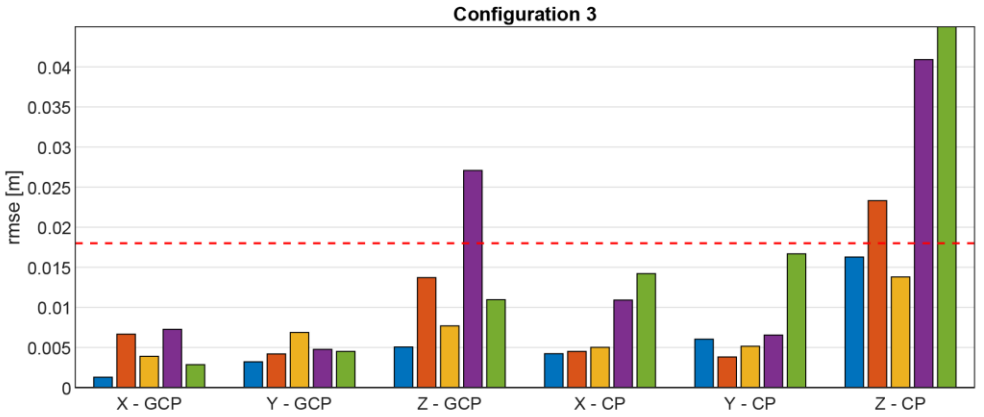


Results 4

- Remembering that GSD is 1.8 cm, results are good for three software:
  - Less 1 GSD in planimetry
  - 1.3 GSD at worst in altimetry
- ContextCapture presents larger value in Z component of Config3
- MicMac needs new camera calibration strategy







Conclusions

- Photoscan, Pix4D and UAS Master showed good results:
  - Less 1 GSD for planimetry
  - Less 1.5 GSD for altimetry
- Context Capture
  - Similar for planimetry
  - Worst in altimetry
- MicMac
  - Large anomalies in altimetric component probably connected to camera calibration
- Decreasing of GCPs influenced more the last two

Further activities

- Influence of oblique imagery on BBA results

- Influence of BBA results and block structure on dense point clouds generation
- Quality will be evaluate:
  - In terms of density, comparing flat and scarp areas
  - In terms of accuracy, assessing the clouds with several check points (already measured)

Thank you!

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