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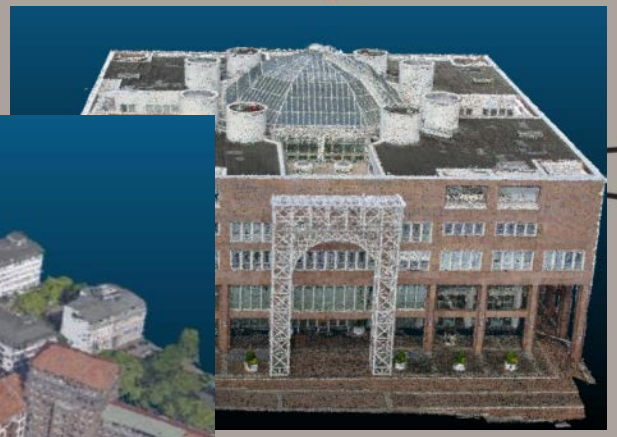
ISPRS/EUROSDR BENCHMARK MULTI-PLATFORM PHOTOGRAMMETRY

PRELIMINARY RESULTS



Francesco Nex
Markus Gerke

October 19, 2015

ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

CONTENT

1. Brief overview: oblique airborne photogrammetry
2. EuroSDR Questionnaire
3. ISPRS/EuroSDR Benchmark on multi-view photogrammetry
4. Priliminary results (image orientation)

THE FIRST AIRBORNE PHOTOS

...WERE OBLIQUE

First recorded aerial photograph in the US (Boston),

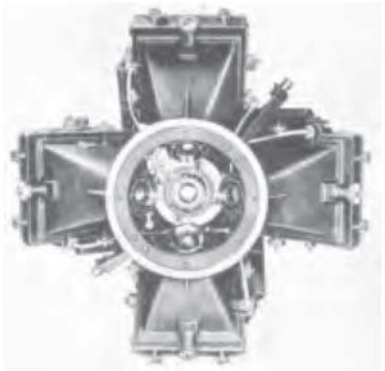
by James Wallace Black, 1860, source Wikipedia

THE FIRST AIRBORNE PHOTOS

…WERE OBLIQUE

First recorded aerial photograph in the US (Boston), by James Wallace Black, 1860, source Wikipedia

- Intuitively the operator shot from a slanted angle
- Recognition of buildings
- In the 1930's: USGS and military systematically captured oblique images

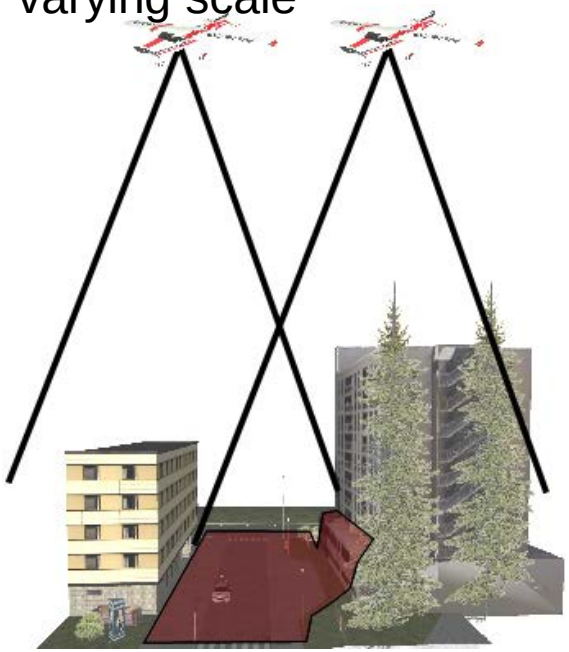


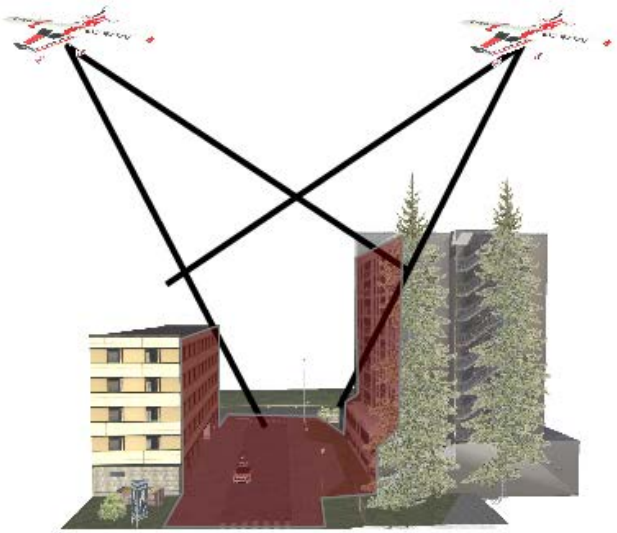
Fairchild T3-A camera, source Petrie (2009)

PROPERTIES
SCENE OBSERVATION

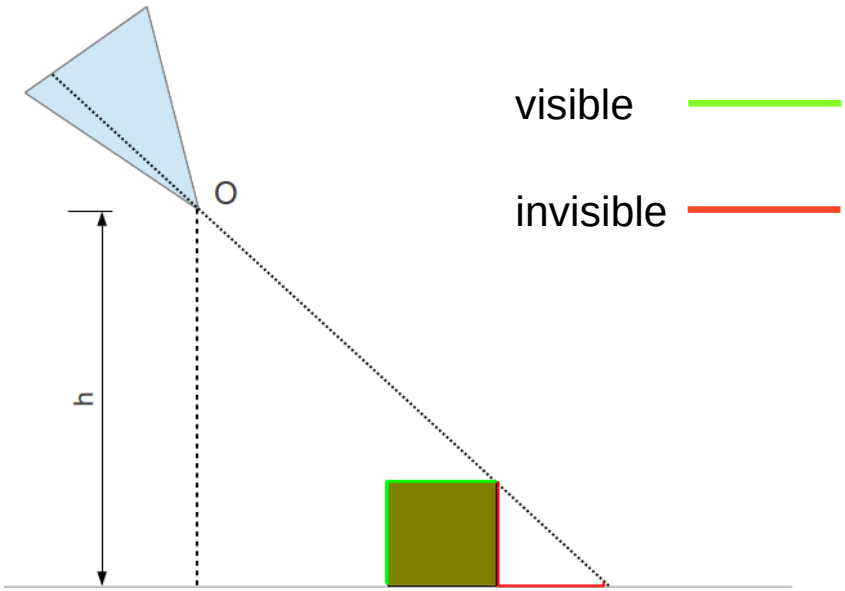
Vertical/nadir images: good observation of ground features and roof structures, assume constant scale

Oblique images: observation of vertical structures, but occlusion more dominant, varying scale



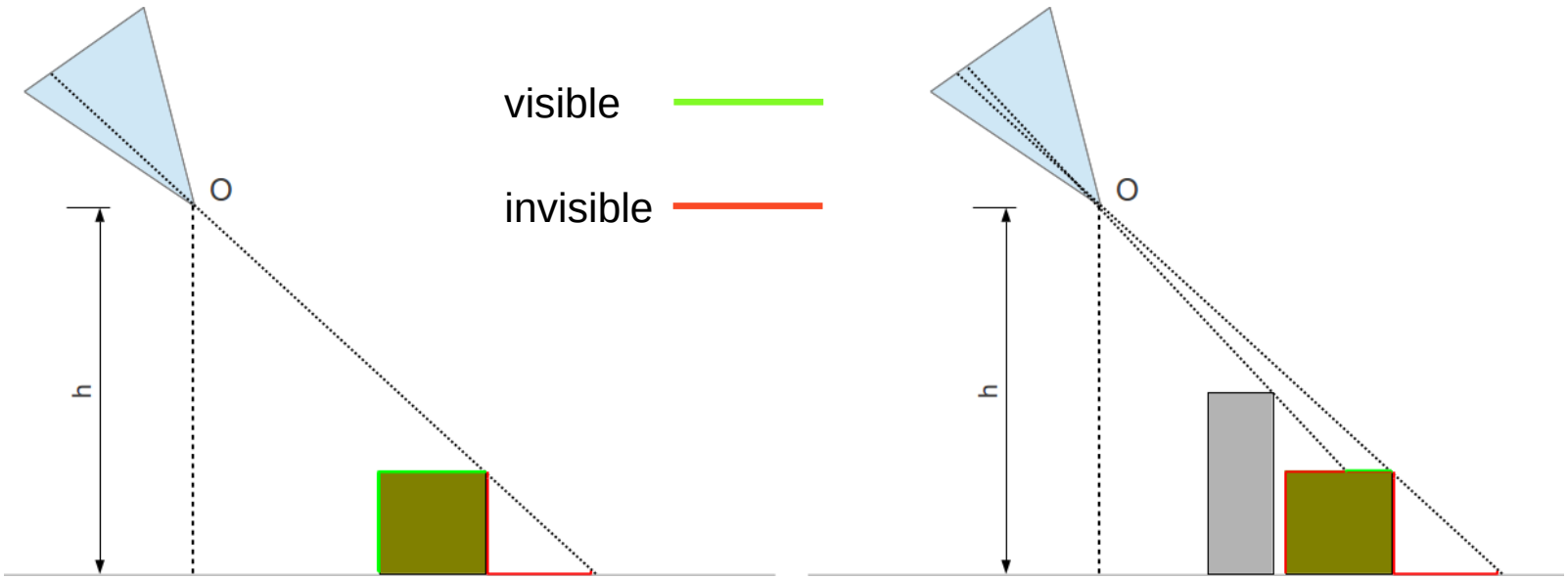


PROPERTIES
OCCLUSION



“Self-” occlusion

PROPERTIES
OCCLUSION

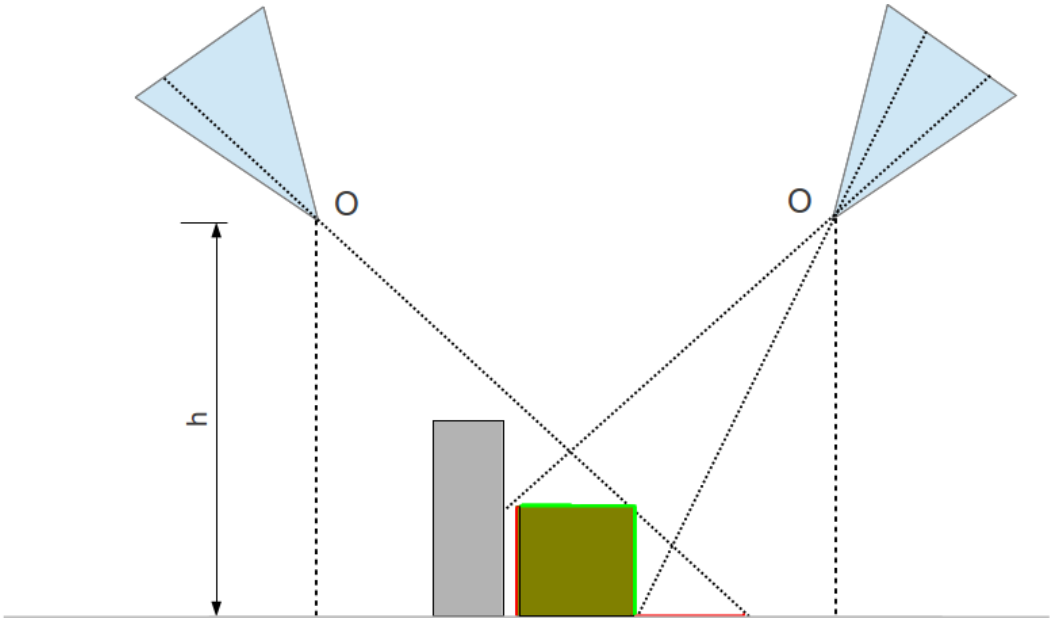


"Self-" occlusion

Occlusion by other objects

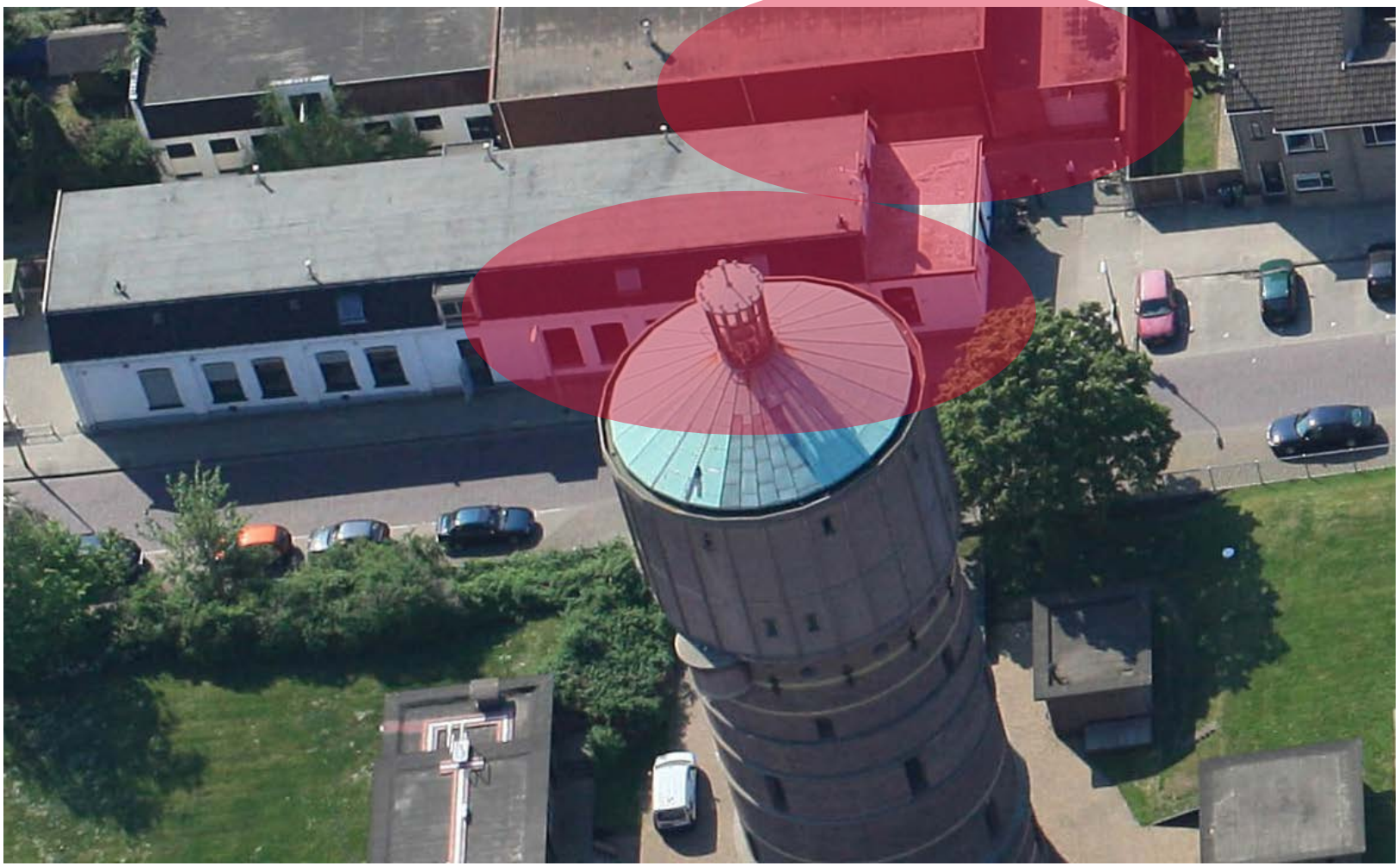
PROPERTIES
OCCLUSION

Mitigation through multiple view and overlap

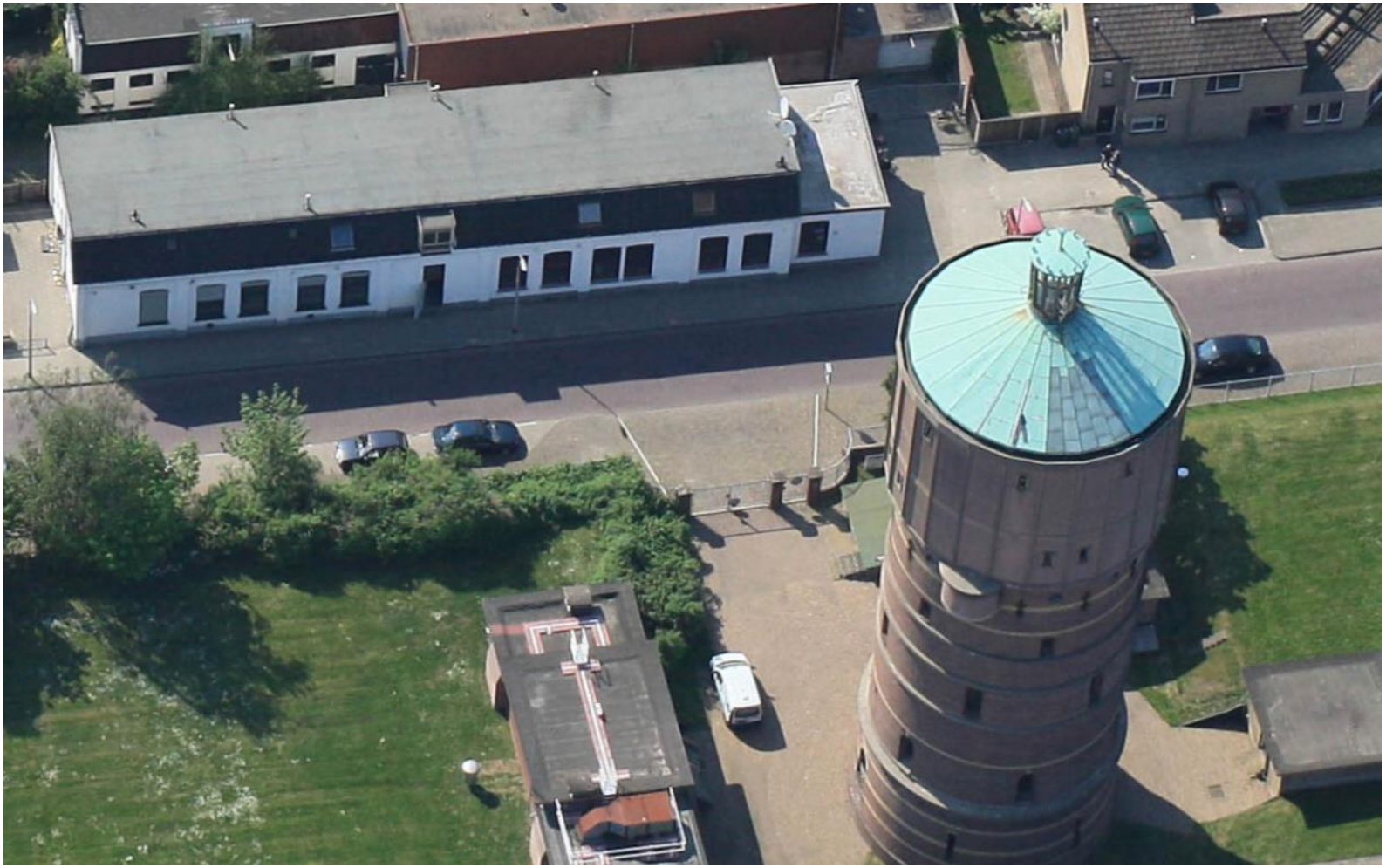


PROPERTIES

OCCLUSION - EXAMPLE



PROPERTIES
OCCLUSION - EXAMPLE

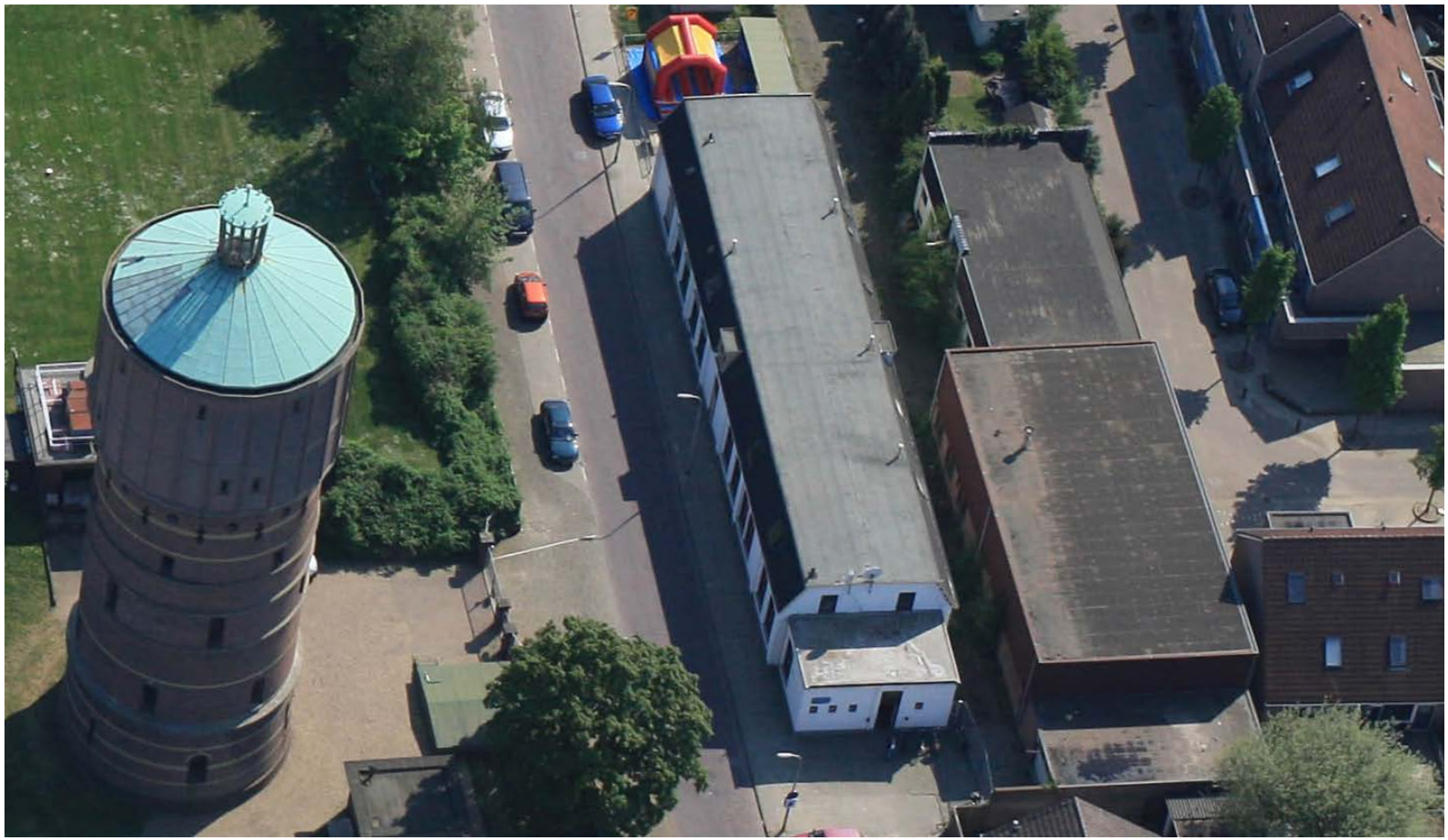


All images © Slagboom en Peeters

PROPERTIES
OCCLUSION - EXAMPLE

PROPERTIES

OCCLUSION - EXAMPLE



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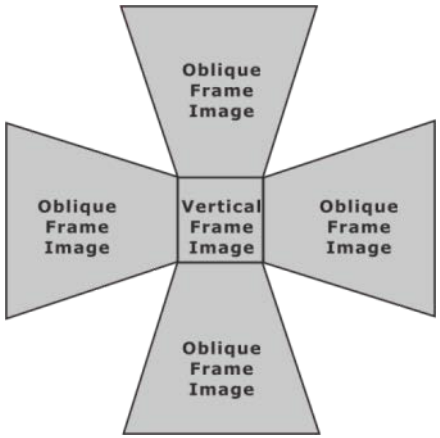
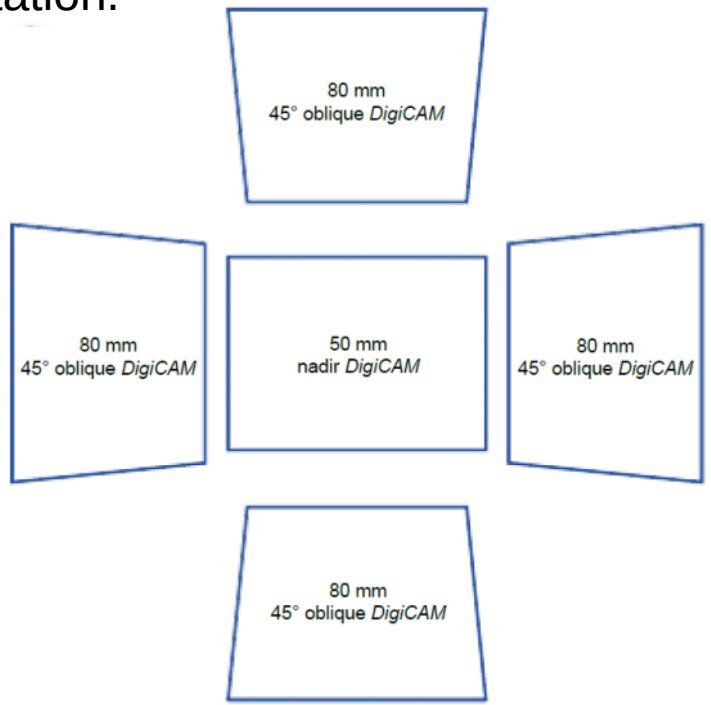
PROPERTIES
MALTESE CROSS CONFIGURATION

Maltese Cross configuration: one vertically pointing camera and 4 highly obliques pointing to the four cardinal directions. Used mainly for visualisation and (urban) data interpretation.



Source: Petrie, 2009



IGI Penta DigiCAM, Source: Homepage IGI

PROPERTIES
MALTESE CROSS CONFIGURATION

Maltese Cross configuration: one vertically pointing camera and 4 highly obliques pointing to the four cardinal directions. Used mainly for visualisation and (urban) data interpretation.

Companies offering such systems, eg:

- Track'Air MIDAS

Modular mid format systems, eg:

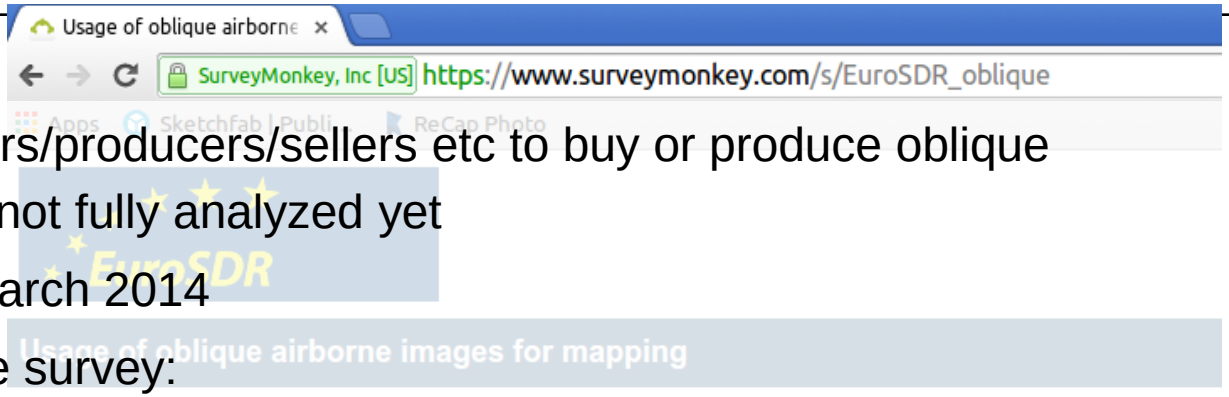
- IGI Penta DigiCam (RGB or CIR)
- Hexagon/Leica 5 camera head, mid format camera RCD30. RGB (plus optional NIR in all cameras)
- Microsoft Osprey 5 camera head, NIR only in nadir

➔ See also **other presentations today and tomorrow** and January to May 2014 issues of the GIM international magazine for an overview

Leica Oblique 5-camera head, source homepage Leica

EUROSDR QUESTIONNAIRE

ON USE OF AIRBORNE OBLIQUE IMAGES FOR MAPPING



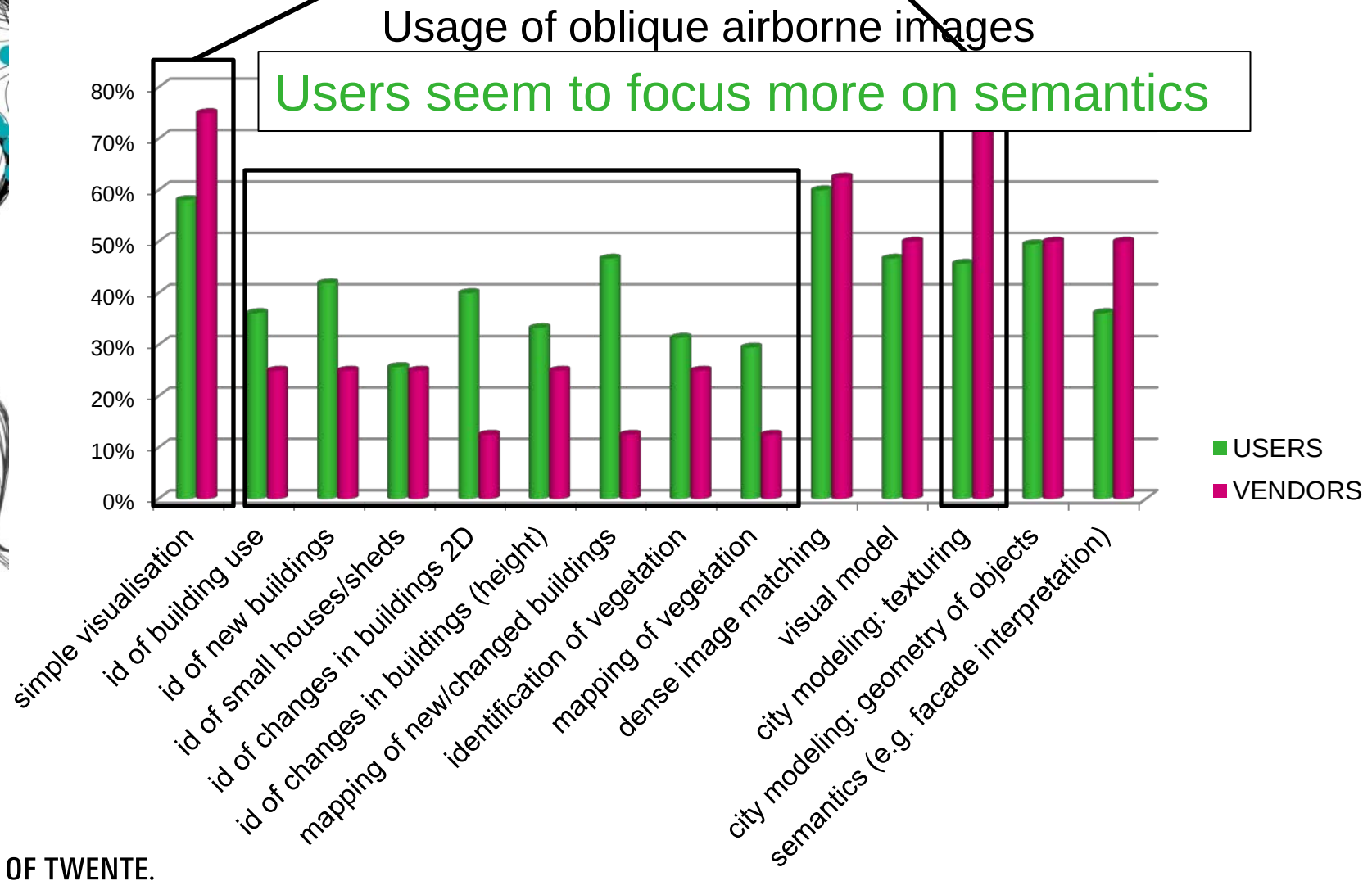
- Motivation of users/producers/sellers etc to buy or produce oblique airborne images not fully analyzed yet
- Put online end March 2014
- Key figures of the survey:
  - Separation user of images /software or hardware vendor
  - About 10 questions
  - Around 130 participants from NMCAs, academia, municipalities, vendors, etc.

  - *Here we just provide a short overview, a more complete presentation is available on http://www.itc.nl/resumes/gerke*

Vendors seem to focus more on visualisation

USAGE OF OBLIQUE AIRBORNE IMAGERY

EUROSDR QUSTIONNAIRE



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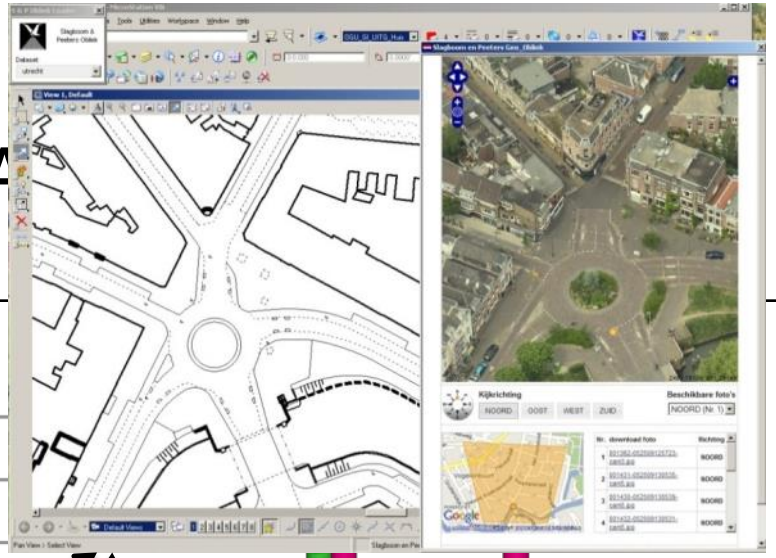
OBLIQUE A
NNAIRE

Usage of



60%
50%
40%
30%
20%

id of chan
id of cha
visual model
modeling: texturing
modeling: geometry of objects
emantics (e.g. facade interpretation)

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EUROSDR QUESTIONNAIRE

More conclusions from the questionnaire

- more “intuitive” than nadir-only viewing
- much more information (like number of floors/usage)
- however: automation in image processing not yet matured
- ➔ one task to be solved: block adjustment
- ➔ open questions: tie point matching across views? Is the (theoretically) better intersection geometry actually exploited? …
- ➔addressed in the EuroSDR/ISPRS benchmark on multi view photogrammetry

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AIM OF THIS BENCHMARK

Foster research concerning:

1) Fully automatic and reliable co-registration of multi platform/perspective imagery (Data available since September 2015)

2) Dense image matching within/across platforms (data available since Spring 2015)

terrestrial image blocks

UAV (nadir/oblique)

conventional airborne (nadir/oblique)

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Area 1: Dortmund City Centre (used for image orientation benchmark)

OBLIQUE SYSTEM

- *IGI PentaCam (80/80%), released 60/60%,*
- *GSD 10cm – 1260* images (yellow area)

UAV *(3 selected buildings)*

- oblique/nadir,
- GSD 1-2cm (red area)

TERRESTRIAL *(3 selected buildings)*

- GSD < 1cm (red area)

REFERENCE DATA

- GNSS, total station
- TLS, ALS

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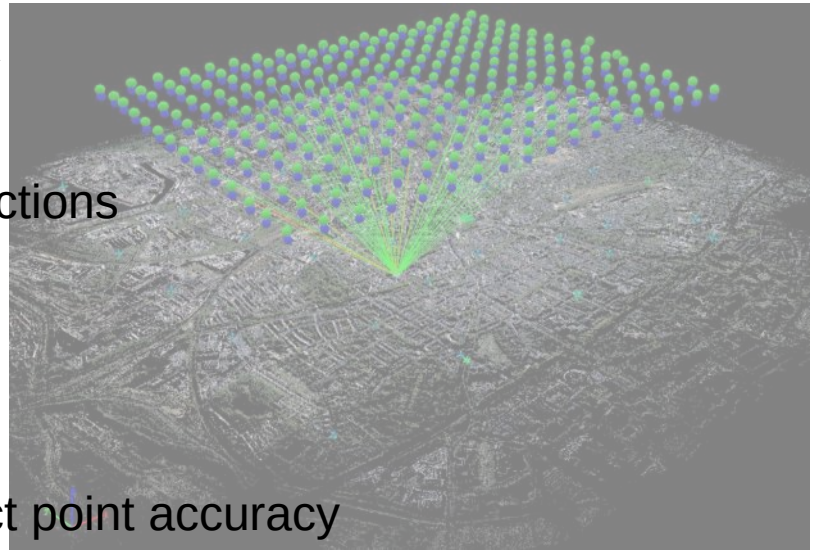
Preliminary results for PentaCam BBA



Focus:

- Tie point matching across viewing directions
- Nadir-only setup vs PentaCam
- Lab calibration vs. self calibration
- 80/80 vs 60/60
- Distribution of GCP, influence on object point accuracy
- Software dependency

- Preliminary tests with Pix4d and by Karsten Jacobsen (BLUH)

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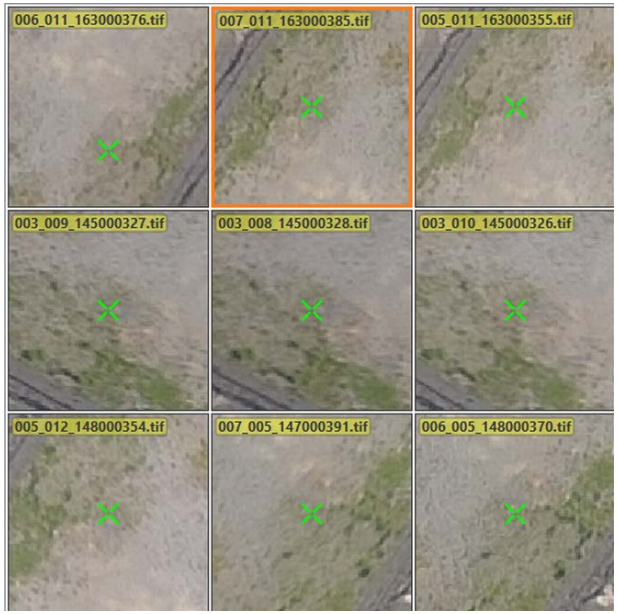
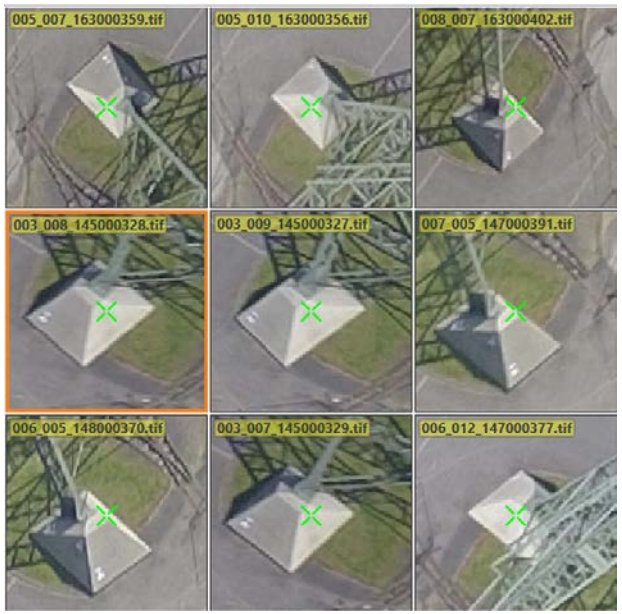
Analysis of tie point matching across viewing directions





- One main obstacle: to find matches between cameras on the platform: perspective transformation, occlusion
- Analysis using pix4d: 60/60 vs 80/80 flight

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Analysis of tie point matching across viewing directions

60/60

Median / 75%/ Maximal Number of Matches Between Camera Models

	NADIR	RIGHT	BACK	LEFT	FRONT
NADIR	121 / 433 / 2973	18 / 62 / 581	21 / 79 / 1423	11 / 51 / 689	23 / 72 / 996
RIGHT		103 / 792 / 4730	3 / 6 / 70	3 / 10 / 46	3 / 7 / 43
BACK			39 / 291 / 4709	3 / 8 / 45	3 / 8 / 81
LEFT				44 / 278 / 5162	4 / 7 / 42
FRONT					64 / 309 / 4664

- Nadir-to-oblique-views 6times less matches as nadir-to-nadir
- Only little number of matches across oblique viewing directions

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Analysis of tie point matching across viewing directions

80/80

Median / 75%/ Maximal Number of Matches Between Camera Models

	RIGHT	BACK	FRONT	LEFT	NADIR
RIGHT	138 / 738 / 6232			274 / 808 / 9442	4 / 21 / 574
BACK		133 / 566 / 6560	197 / 767 / 5423	1 / 1 / 1	10 / 39 / 588
FRONT			134 / 588 / 6675	1 / 1 / 1	9 / 34 / 584
LEFT				127 / 711 / 6553	3 / 7 / 227
NADIR					263 / 865 / 5795

- Compared to 60/60 in general more matches across different views, but partly no matches (eg Right vs Back/Front)
- Cameras which share same cardinal direction (front/back, left/right) have many mutual matches.

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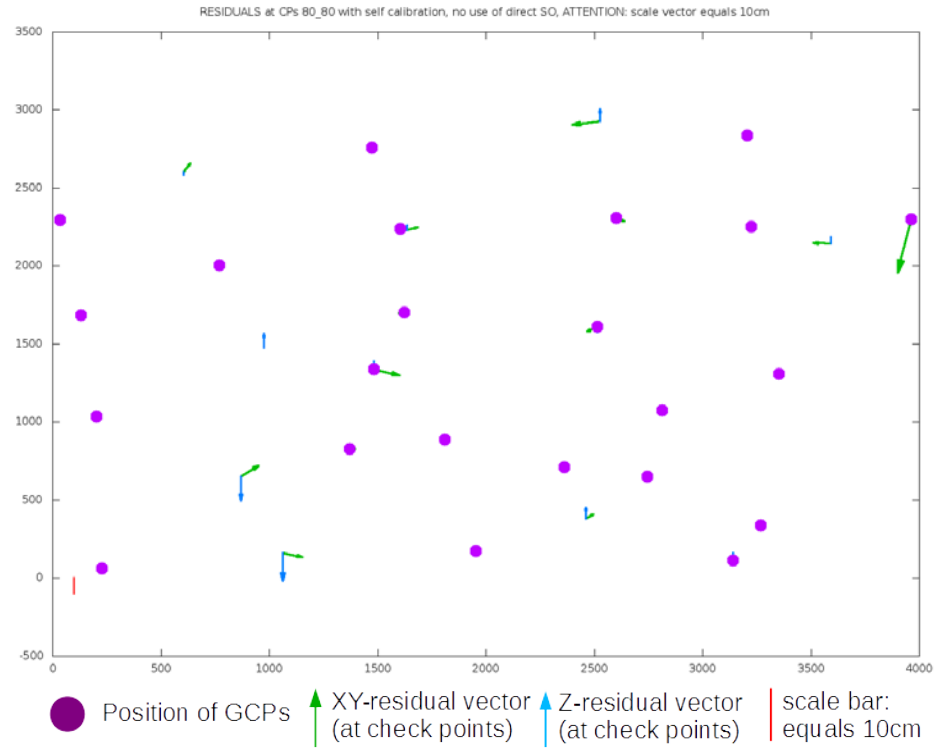
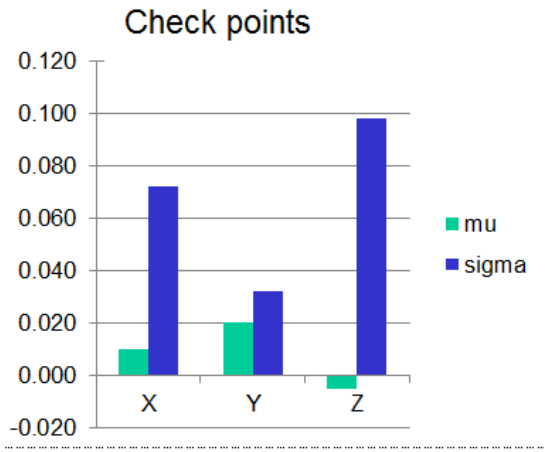
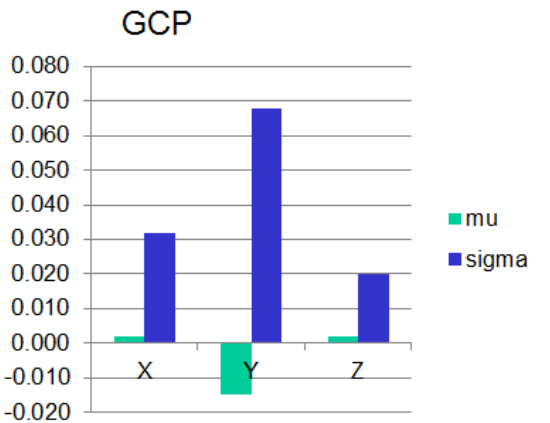
Analysis of influence of calibration strategy/GCP distribution

1) 80/80, PentaCam, good GCP distribution, self-calibration, Pix4D







- Systematic effects not visible
- block deformation not obvious
- Sigma in GSD level (10cm) or even smaller.

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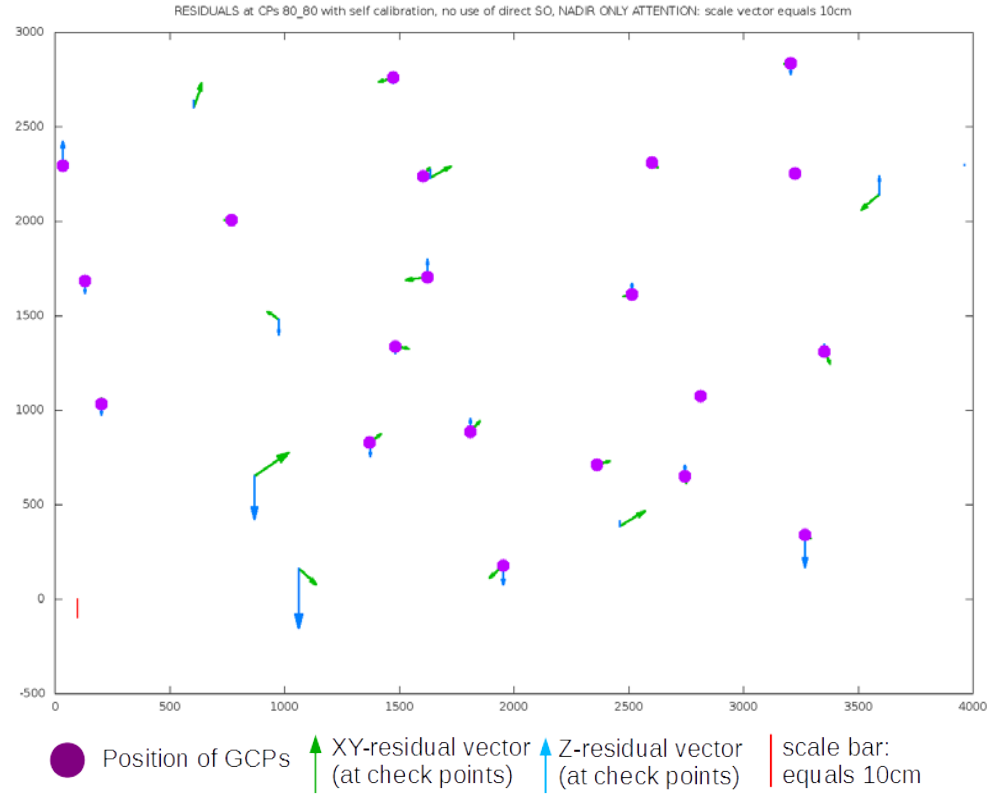
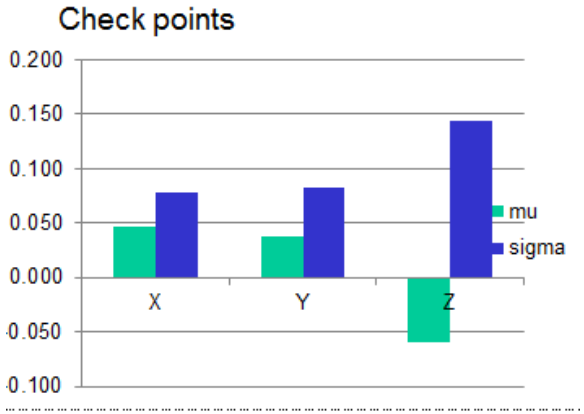
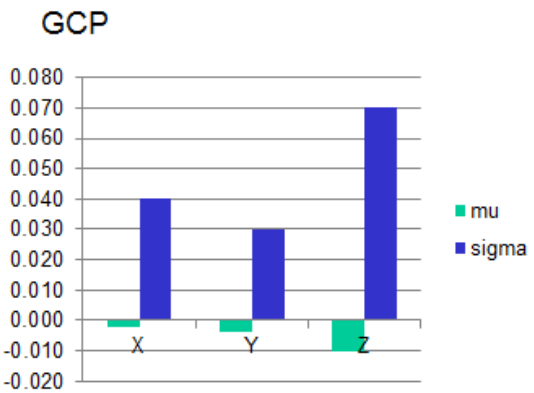
Analysis of influence of calibration strategy/GCP distribution

2) 80/80, **NADIR only**, good GCP distribution, self-calibration, Pix4D







- Especially Z-error significantly larger compared to Penta (10 vs 14 cm)

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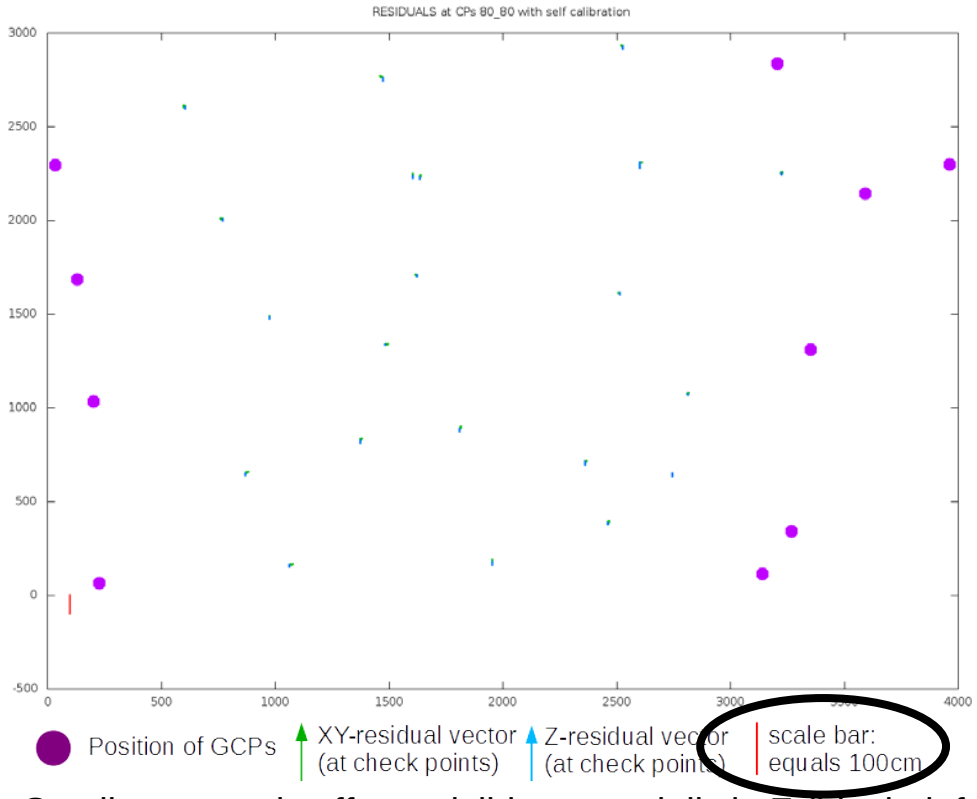
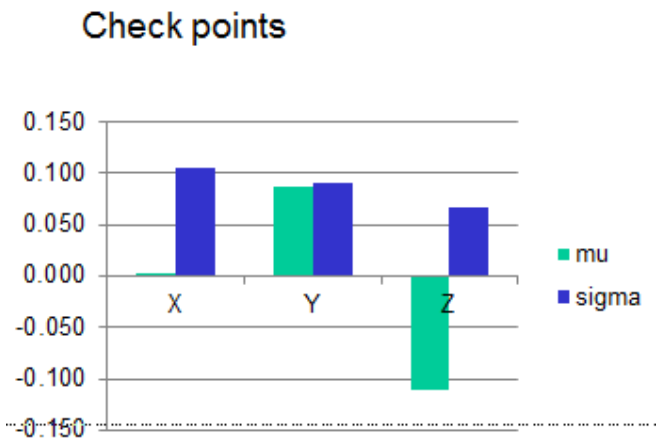
Analysis of influence of calibration strategy/GCP distribution

3) 80/80, **Penta, Benchmark GCP distribution**, self-calibration, Pix4D





- Small systematic effects visible, especially in Z (block deformation)
- Sigma in GSD level (10cm) or even smaller, not much worse compared to full GCP distribution

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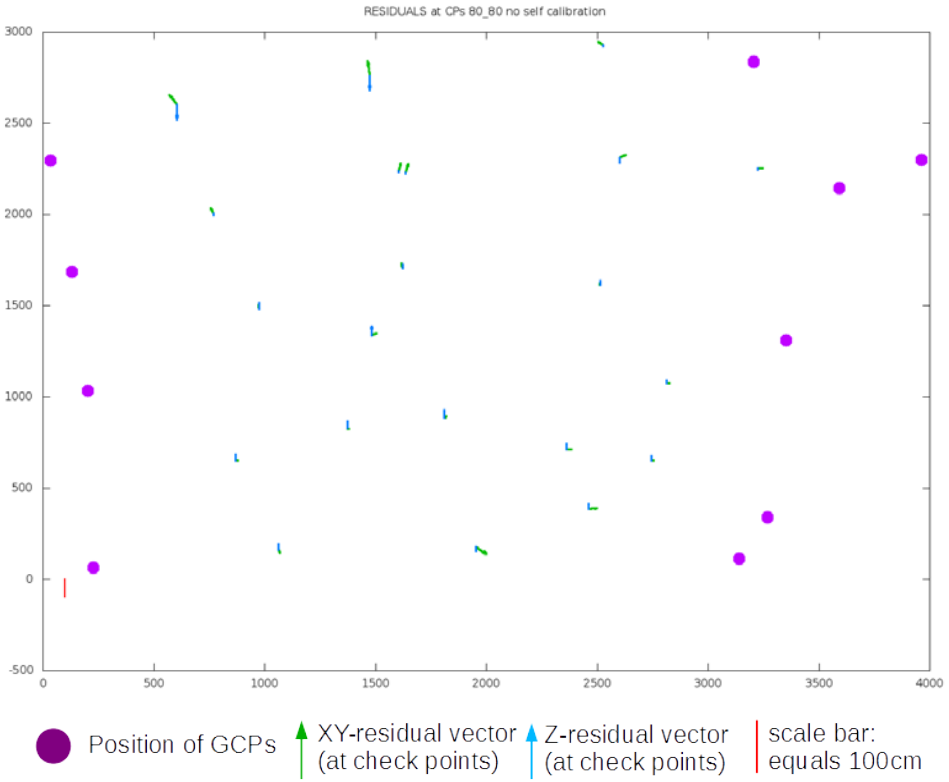
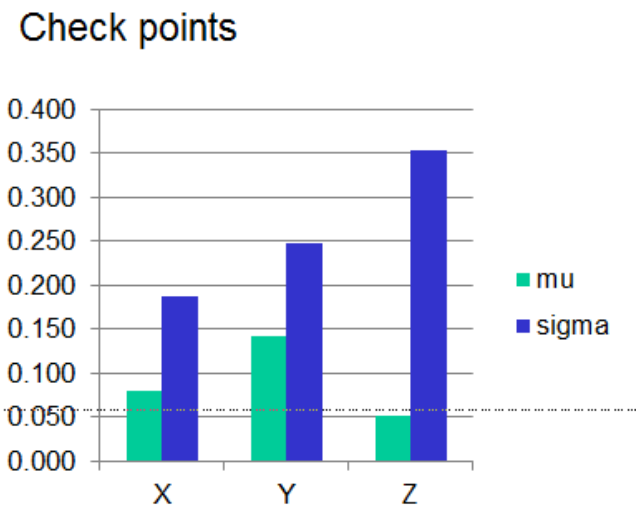
Analysis of influence of calibration strategy/GCP distribution

4) 80/80, Penta, Benchmark GCP distribution, **no self-calibration**, Pix4D





- Block deformation larger compared to self-calibration
- *Sigma up to 3xGSD*

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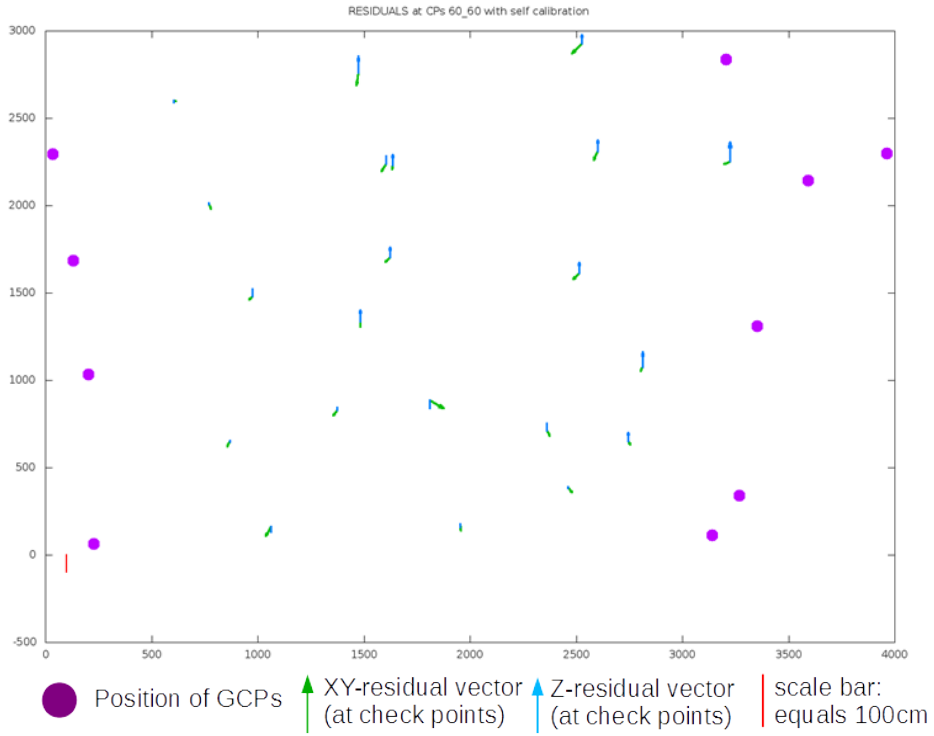
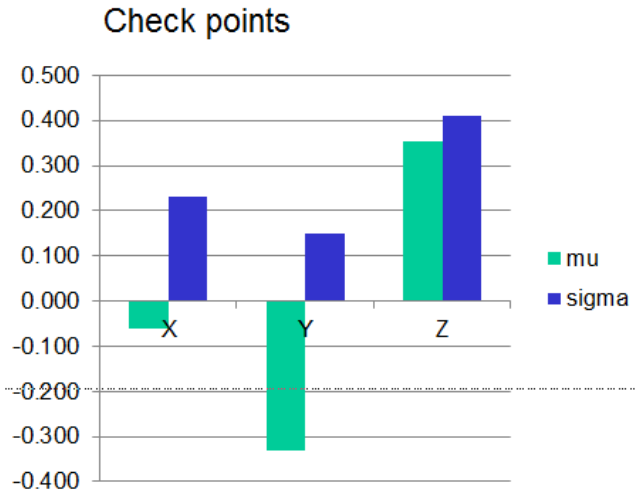
Analysis of influence of calibration strategy/GCP distribution

5) 60/60, Penta, Benchmark GCP distribution, self-calibration, Pix4D





- Large systematic effects visible, block deformation obvious. Compared to 80/80 (3) 3 times worse results
- Sigma up to 40cm in Z

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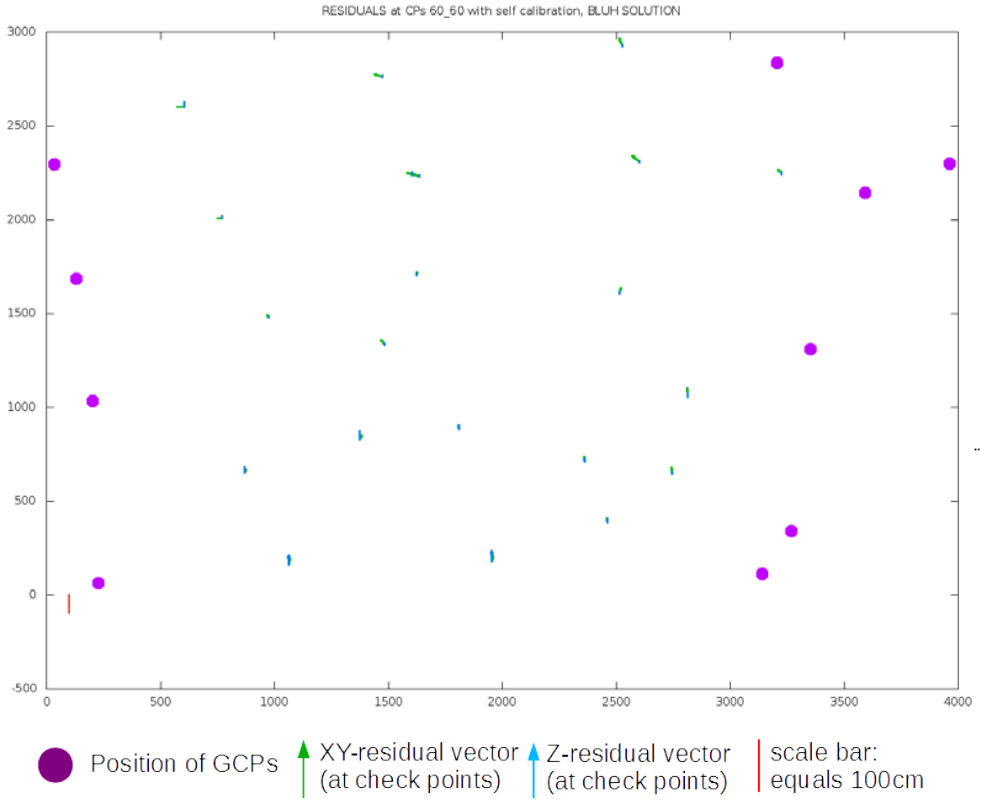
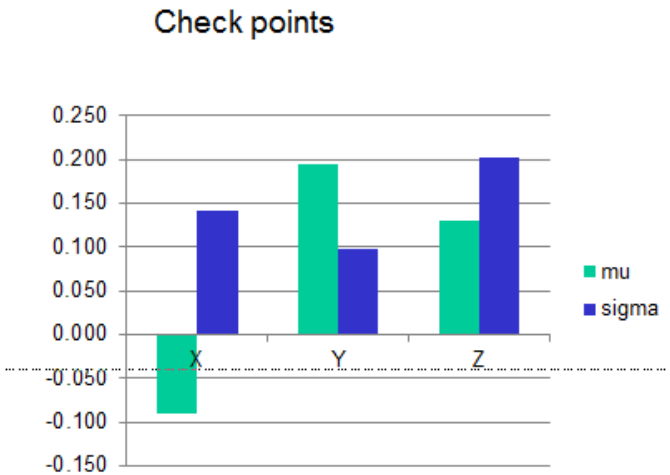
Analysis of influence of calibration strategy/GCP distribution

6) 60/60, Penta, Benchmark GCP distribution, self-calibration, **BLUH** solution





- Systematic effects significant, up to 20cm shift in Y,
- Sigma smaller compared to pix4d (up to 20 vs. 40cm in Z)

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Preliminary conclusions 1/2

- Tie point matching across viewing directions: needs to be enhanced – interest points/lines/areas invariant to perspective transformations? Object-based tie features? How to handle occlusion?

- Nadir-only vs Penta (experiments 1,2): Height estimation better in Penta, only tested with 80/80 though

- Lab calibration vs. self calibration (3,4): self-calibration preferred (however, in case of our data uncertainties regarding definition of parameters within pix4d, lens distortion parameters not really transferrable)

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Preliminary conclusions 2/2

- 80/80 vs. 60/60 (3,5): Random and systematic error worse by factor 3 in 60/60 (but attention: unfavorable GCP distribution from benchmark)
- Distribution of GCP, influence on object point accuracy (1,3): systematic error a bit larger in benchmark GCP distribution, random error comparable
- Software dependency (5,6): no thorough test yet; in one comparison the accuracy obtained with BLUH is a bit better than from Pix4D ➔ self-calibration parameters better suited?

Thank you for your attention.

Markus Gerke, Francesco Nex

Questions?

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