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ACCURACY ASSESSMENT OF THE FARO FOCUS^{3D} AND LEICA HDS6100 PANORAMIC TYPE TERRESTRIAL LASER SCANNER THROUGH POINT-BASED AND PLANE-BASED USER SELF-CALIBRATION

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Manufacturer's Spec. (1/2)

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		ocus^{3D}	
Archit		noramic	
HFOV		0º/305º	
Range princi		se-based	
Scan		000Hz	
Unam		3.49m	
Spot s		+ 0.16mra	
Range @ 90%		n (0.50mm	
Range @ 90% albedo	± 2mm		≤ 2mm

GEOMATICS ENGINEERING

Manufacturer's Spec. (2/2)

	Focus^{3D}	HDS6100
Weight	5kg	14kg
Size	240x200x100mm	294x199x360mm
Operating temperature	5°C – 40°C	-10°C – 45°C
Levelling sensor	Dual-axis compensator	Dual-axis compensator
Heading sensor	Electronic compass	N/A
Height sensor	Barometer	N/A
RGB	Built-in camera	N/A
Price	$	$$$
	http://www.faro.com/focus/uk	http://hds.leica-geosystems.com/en/

Motivation

Can the low-cost Faro Focus^{3D} deliver the same level of precision and accuracy as the Leica HDS6100?

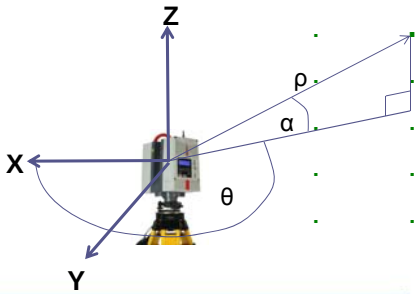
Methodology (1/7)

Methodology (2/7)

$$\rho_{ij} = \sqrt{x_{ij}^2 + y_{ij}^2 + z_{ij}^2} + \Delta\rho$$

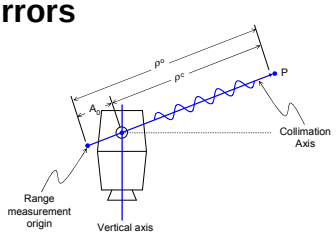
$$\theta_{ij} = \tan^{-1}\left(\frac{y_{ij}}{x_{ij}}\right) + \Delta\theta$$

$$\alpha_{ij} = \tan^{-1}\left(\frac{z_{ij}}{\sqrt{x_{ij}^2 + y_{ij}^2}}\right) + \Delta\alpha$$

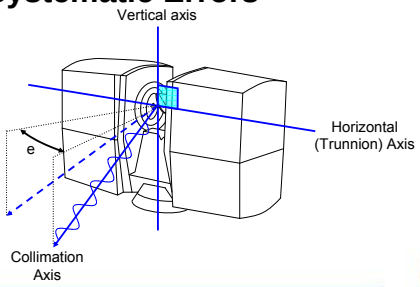


Methodology (3/7)

Range Systematic Errors

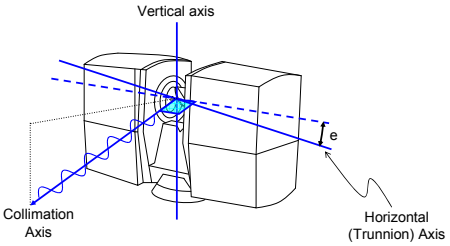


Horizontal Circle Systematic Errors

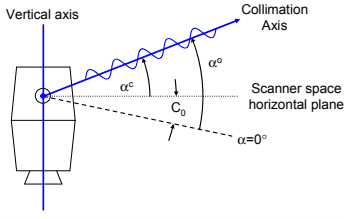


Methodology (4/7)

Horizontal Circle Systematic Errors

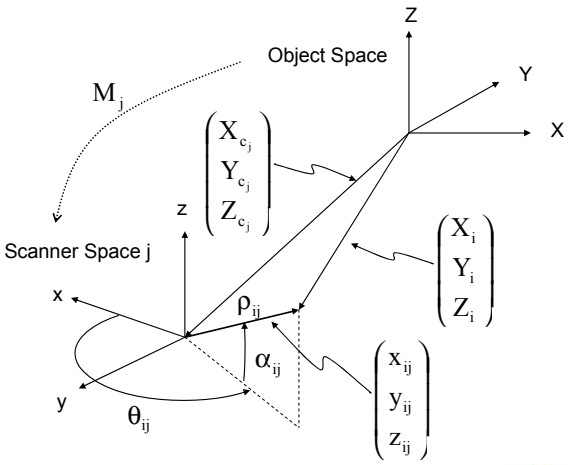


Vertical Angle Systematic Errors



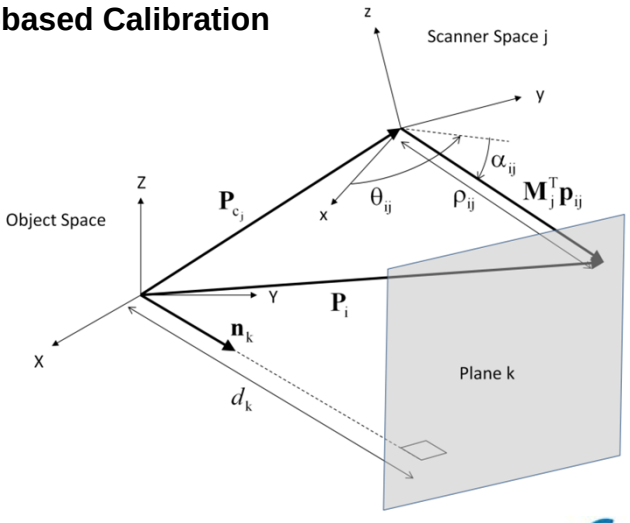
Methodology (5/7)

Point-based Calibration



Methodology (6/7)

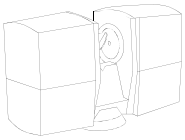
Plane-based Calibration



Methodology (7/7)

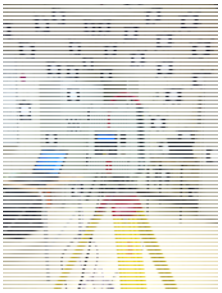
Additional observations

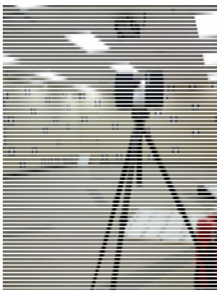
$$\alpha = \alpha_{obs} \pm c_{\omega}$$
$$\varphi = \varphi_{obs} \pm c_{\phi}$$
$$\kappa = \kappa_{obs} \pm c_{\kappa}$$



Experiment (1/1)

Small Room
5 m by 5m by 3m





Large Room
14 m by 11 m by 3 m

Results (1/5)

Dual-axis Compensator

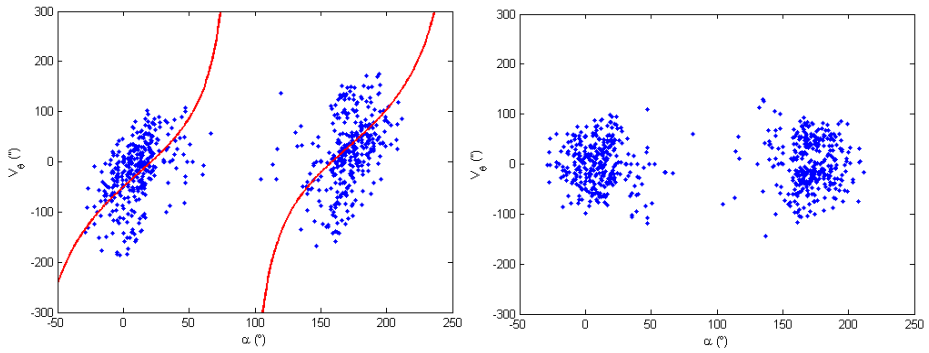
Scanner	Manufacturer	Determined
Focus^{3D}	54”	346”
HDS6100	7.2”	133”

Digital Compass

Scanner	Determined
Focus^{3D}	40”

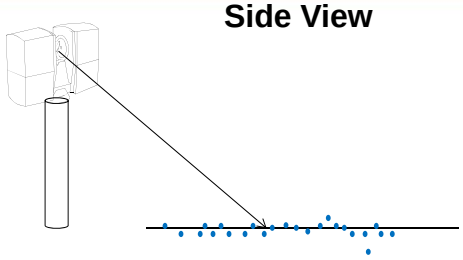
Results (2/5)

Horizontal circle residuals as a function of elevation angle

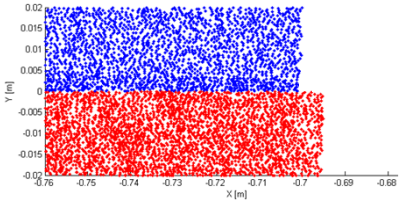


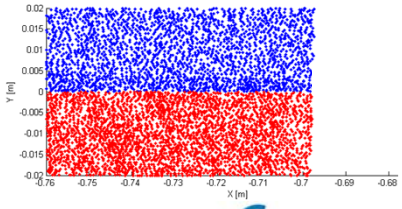
Results (2/5)

Side View

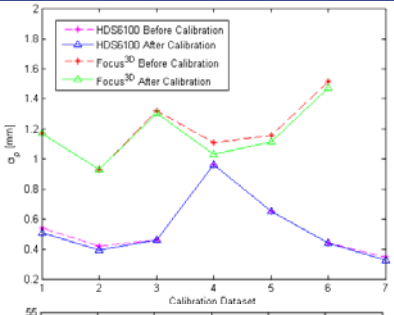


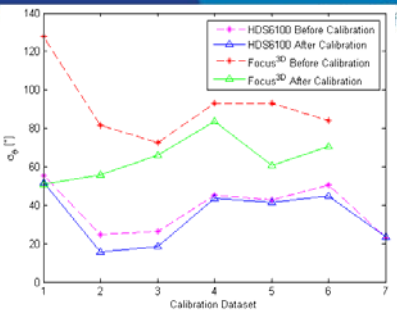
Top View

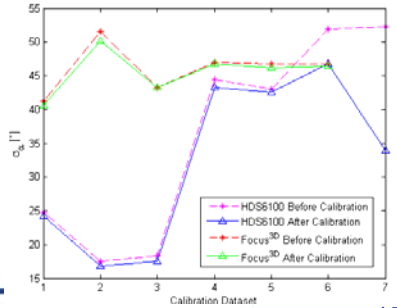




Results (3/5)







	HDS6100			Focus^{3D}		
	Before	After	Improv	Before	After	Improv
σ_ρ [mm]	0.55	0.53	2.2%	1.20	1.17	2.6%
σ_θ ["]	38.4	34.2	11.0%	92.0	64.8	29.6%
σ_α ["]	36.0	32.1	10.8%	46.1	45.6	1.1%

Results (4/5)

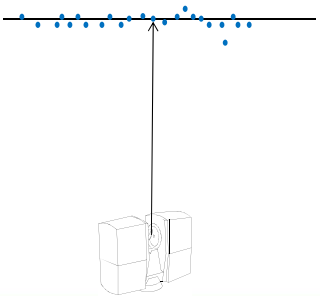
Recovered systematic errors for the Focus^{3D} through point-based and plane-based self-calibration

Dataset	Range offset	Horizontal circle eccentricity		Non-orthogonality of encoder & vertical axis		Collimation axis error	Trunnion axis error	Vertical circle index error	Non-orthogonality of encoder & trunnion axis	
1				13.6 ± 3.1	10.9 ± 3.2	87.4 ± 4.5	-203.8 ± 8.8			
2	0.54 ± 0.23	-27.5 ± 9.2	-51.8 ± 3.6			50.3 ± 2.9	-138.3 ± 6.8		24.2 ± 4.4	
3	1.12 ± 0.23					49.6 ± 4.8	-32.6 ± 9.8			12.3 ± 2.8
4	2.12 ± 0.31		-54.5 ± 5.2				44.2 ± 9.8			
5	0.48 ± 0.18					58.1 ± 2.2	-49.6 ± 3.6	-37.3 ± 7.5		
6	0.96 ± 0.23					50.2 ± 2.7	-59.1 ± 4.1	-38.9 ± 8.1		
7	2.02 ± 0.42					102.0 ± 6.5	-113.3 ± 17.7	128.7 ± 13.0		

Results (5/5)

Differences between the signalised target positions determined by the HDS6100 and Focus^{3D}

	Before Calibration [mm]			After Calibration [mm]		
Room	$RMSE_X$	$RMSE_Y$	$RMSE_Z$	$RMSE_X$	$RMSE_Y$	$RMSE_Z$
Small	0.7	0.8	0.5	0.7	0.7	0.5
Large	0.6	0.8	2.2	0.5	0.8	1.4



Conclusion

- Modelled systematic errors in the FARO Focus^{3D} and Leica HDS6100 using point-based and plane-based self-calibration
- Raw observations of the HDS6100 are more precise than the Focus^{3D}
- At close-range, the 3D object space reconstructed by both scanners are comparable
- Future work will improve the calibration routine for modelling errors in the Focus^{3D}

Acknowledgments

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Thank You!

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