The Geometrical Quality of Terrestrial Laser Scanner

Presented

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Comparison Measurement and Modeling

Tacheometer

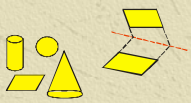
- a few points are observed precisely
- Points are representative
- effort per point is high
- "Think" in 3D-points
- Quality -> points

Scanner

- a mass of arbitrary points (regular grid?)
- points are non-representative
- effort per point very small
- "Think" in 3D-elements
- Quality -> geometrical elements

$X_5 = 234.567$
$Y_5 = 56.008$
$Z_5 = -270.443$

$X_{13} = 108.565$
$Y_{13} = 176.123$
$Z_{13} = 6.462$



Specifications manufacturer

Manuf.	Product	Angle	Distance	Position	Element
Callidus	CP 3200	*A*: 0,009°(V) *A*: 0,005°(Hz)	*A*[2]: 5 mm		*A*: ±2,5 mm (plane)
Cyra	HDS 3000	*A*[1]: 60 µrad	*A*: +-4 mm	*A*: 6 mm @ 50 m	*A*: 2 mm (plane)[7]
Iqsun	880	*R*: 0,0011°(V) *R*: 0,00076°(Hz)	*U*[4] :3mm @10m		
Mensi	GS 200	*R*: 32 µrad	*U*[5,6] :1,4–6,5 mm *T*[5,6] :3–10 mm	*R*: 3 mm @ 100 m	
Optech	ILRIS-3D			*A*: 10 mm	
Riegl	LMS Z 420 i	*R*: 0,0025°	*A*: 10 /5 mm[6]	*R*: 5 mm	
Z & F	IMAGER 5003	*R*: 0,018°(V) *R*: 0,01°(Hz)	*L*: 5 mm		

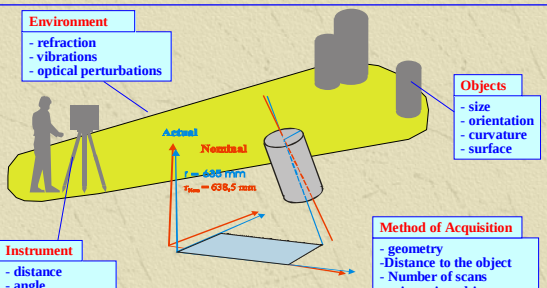
[1]Hz + V [2]typical accuracy [3]depends on averaging
[4]reflectivity of 84% [5]between 5 and 100 m [6]average [7]CYRA 2500

A: Accuracy *L*: Linearity
P: Precision *R*: Resolution
U: Uncertainity *T*: Tolerance

Method 1

Environment
- refraction
- vibrations
- optical perturbations

Objects
- size
- orientation
- curvature
- surface

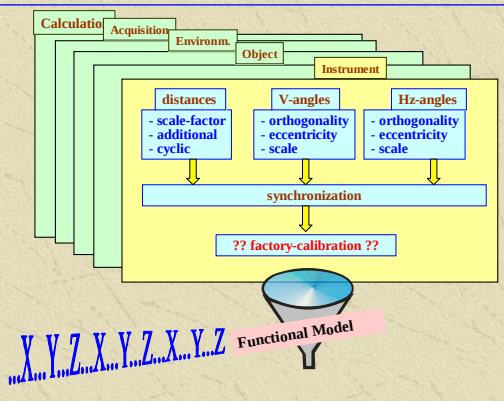


Instrument
- distance
- angle
- Synchronization
- calibration

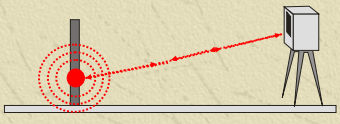
Method of Acquisition
- geometry
- Distance to the object
- Number of scans
- orientation object
- with / without reference

Method of calculation
- registration with tie-points
- calculation of geometrical elements

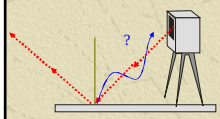
Method 2



Optical Perturbations 1

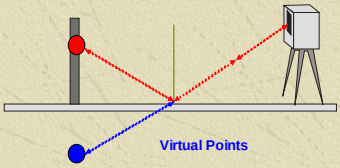


Standard case – 1 diffuse Reflection at the object



Total-Reflection

„Black holes“

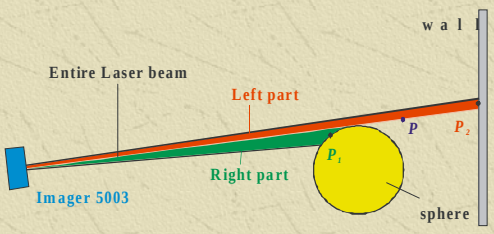


Virtual Points

Total-Reflection combined with diffuse Reflection

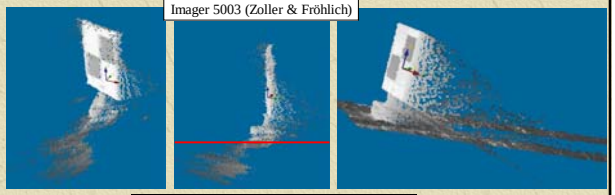
Optical Perturbations 2

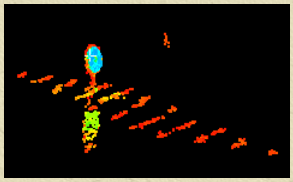
Tail of a Comet



Beispiele

Imager 5003 (Zoller & Fröhlich)

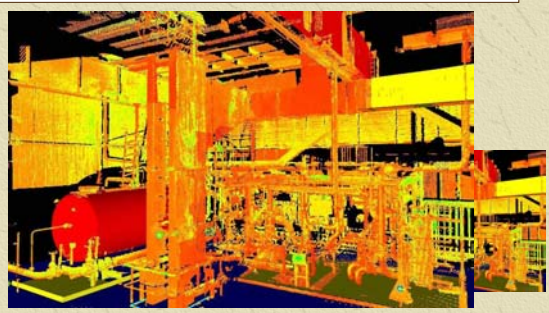




Cyra 2500 (Leica)

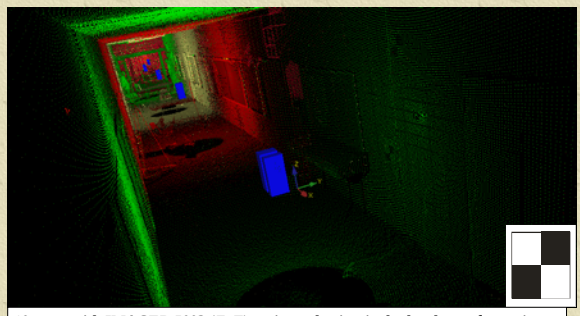
Geometrical Quality?

The geometrical quality of the raw-data (xyz-coordinate) is of fundamental importance….



Calibration of the entire system 2

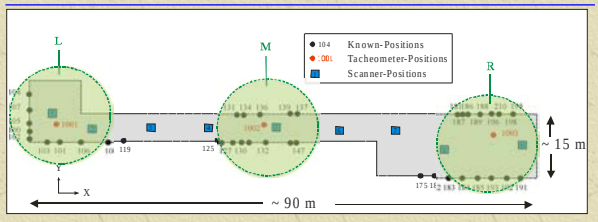
Point clouds



10 scans with IMAGER 5003 (Z+F) registered pair wise by local transformations
Point identification with the standard chess-board-traget
Additional tacheometry (Leica TPS 1200) ~ 50 points in the regions L, M and R

Calibration of the entire system 1

description



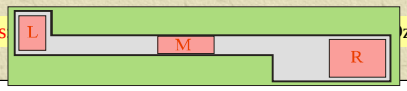
Combined adjustment

observations - local coordinates of Tie-points
- Reference coordinates from tacheometer

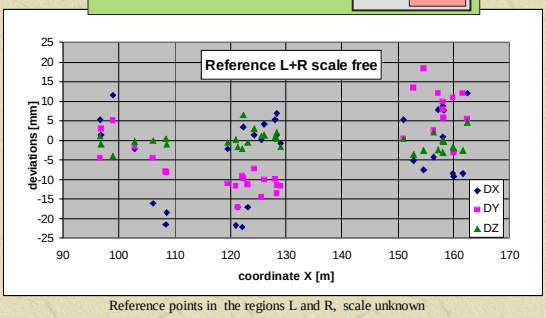
Unknowns - Rotation parameters $R_{21}, R_{32}, \ldots R_{910}$
- coordinates for all Tie-points in the tacheometric system

Calibration of the entire system 3-1

Results LRfree

Deviations 

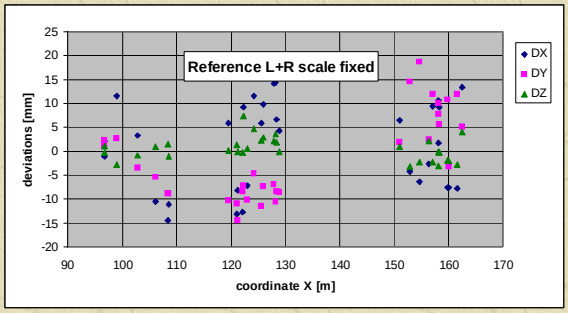
dz = …..



Reference points in the regions L and R, scale unknown

Calibration of the entire system 3-2

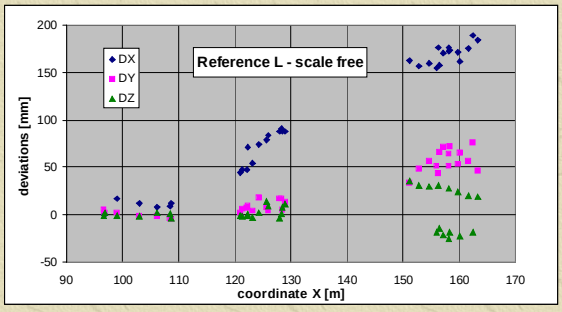
Results LRfixed



Reference points in the regions L and R, scale is fixed to 1.00000

Calibration of the entire system 3-3

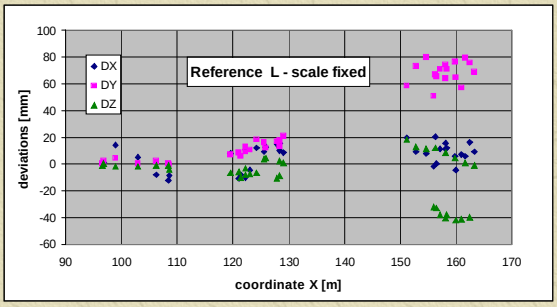
Results Lfree



Reference points in the region L scale is unknown

Calibration of the entire system 3-4

Results Lfixed



Reference points in the region L scale is fixed to 1.00000

Conclusions

System specifications manufacturer…..
not reproducible and not not standardized
Requirement for standardized specifications which can be reproduced
ideal case related to geometrical elements

Geometrical Quality of the scans …..
check on different levels
- measurement noise — Theory and practice
- component methods — distance or angle part
- system calibration method (incl. Registration, Point identification, Geo-referencing, etc…)

System check accuracy
Example: IMAGER 5003 (ZF), 10 scans , Area of 15 X 90 m

good to ideal conditions L+R 10 - 20 mm scale no influence
unfavorable conditions L or R only 100 - 200 mm scale strong influence