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COMPARISON OF GEOMETRIC AND RADIOMETRIC INFORMATION FROM PHOTOGRAMMETRY AND COLOR-ENRICHED LASER SCANNING

Cornelis STAL, Philippe DE MAEYER, Marijke DE RYCK, Alain DE WULF, Rudi GOOSSENS, Timothy NUTTENS

Ghent University, Department of Geography, Ghent (Belgium)
3D Data Acquisition Cluster

Marrakech WW2011

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Content

- Project
- Study Area
- Methodology (6 steps)
  1. Acquisition of the laser point cloud
  2. Acquisition of the photographs
  3. “Texturing” or “Fitting” both images to the point cloud (e.g. using Cyclone software)
  4. Normalisation of the colors of both the “draped photo” and the photogrammetrically produced “orthophoto”.
  5. Computation of the “color difference” for every pixel
  6. Selection of all pixels with significant “color difference
- Conclusion

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Project

- Terrestrial Laserscanning (TLS)
  - + detailed geometric representation
  - - no detailed image with realistic colors
- Terrestrial Photogrammetry (TP)
  - + detailed radiometric representation
  - - very time-consuming restitution

Get the best of both techniques: TLS + HR photo

Research question: Does “TLS+HR photo” deliver comparable results to these of the classical photogrammetry (geometrically and radiometrically) ?

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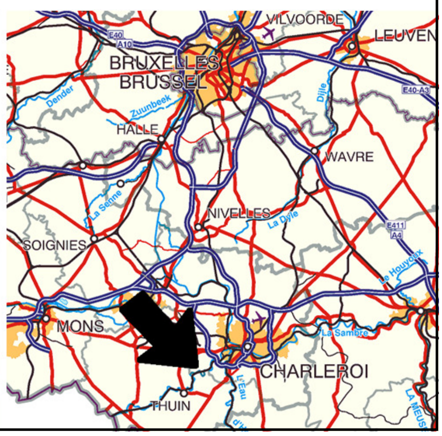
Study Area

Porte de Landelies at the *Abbaye d’Aulne*

Thuin, Belgium (ca. 50 km at the South of Brussels)



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Study Area

Porte de Landelies at the *Abbaye d'Aulne*

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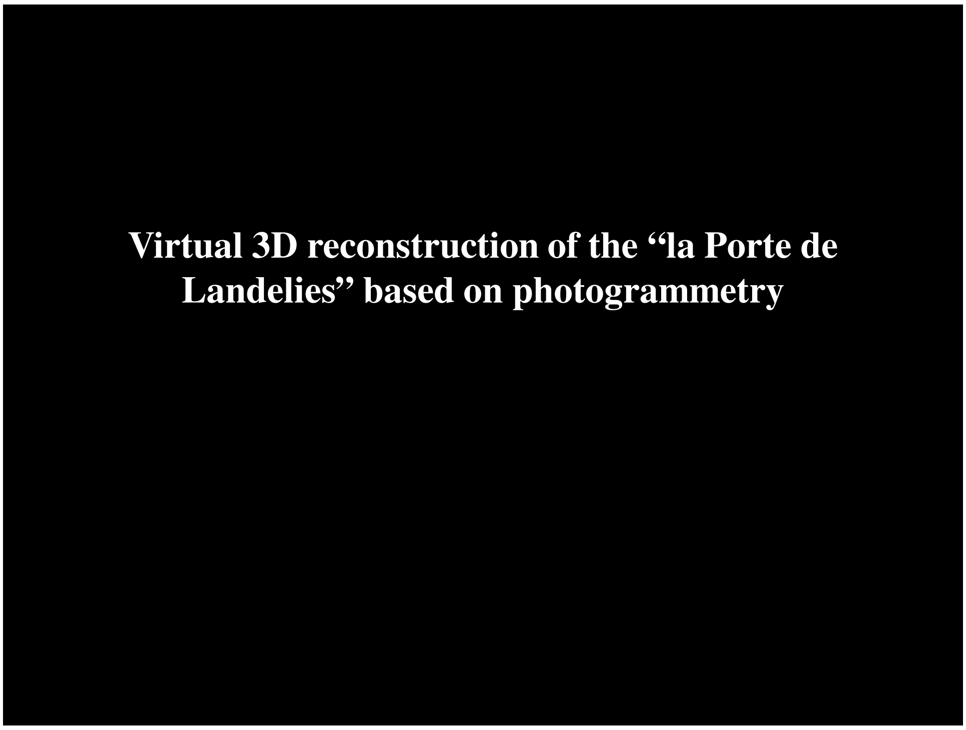
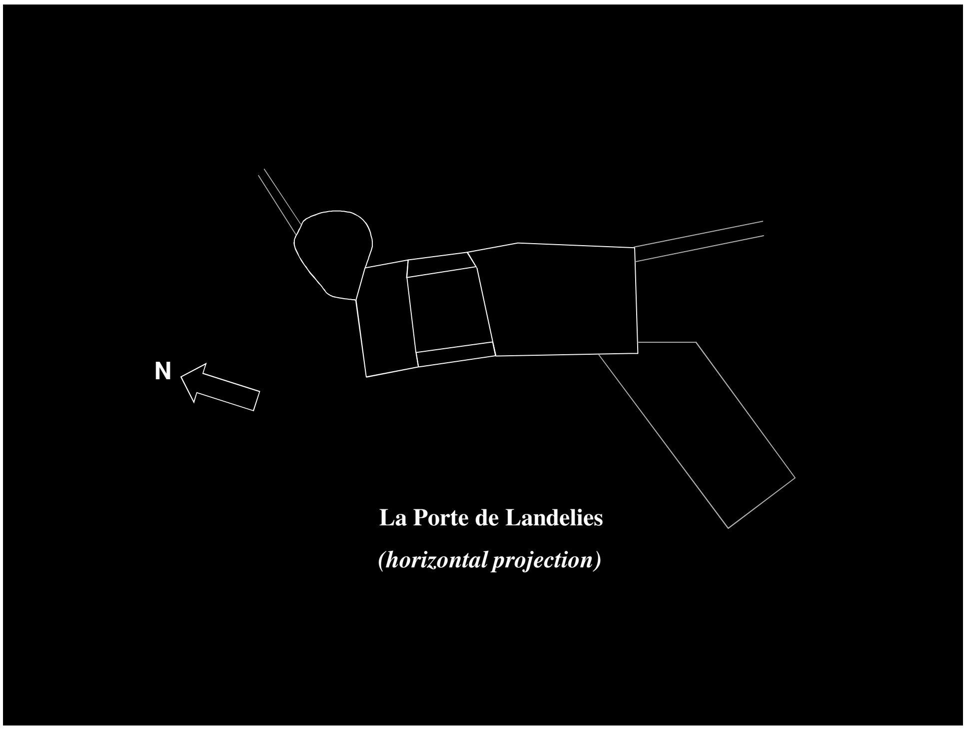
Study Area

Porte de Landelies at the *Abbaye d'Aulne*

- Cictercians Abbay, build between 657 and 879
- Since 15 th century: plundered and destroyed by respectively Burgundians, Beggars, French Royal Army
- 18 th century: partly restored
- 19 th century: partly destroyed in the French Revolution aftermath
- 20 th century: partly rebuild as rest home, a new church and the "Porte de Landelies" gate was reconstructed


Virtual 3D reconstruction of the “la Porte de
Landelies” based on photogrammetry


N
La Porte de Landelies
(horizontal projection)


La Porte de Landelies


La Porte de Landelies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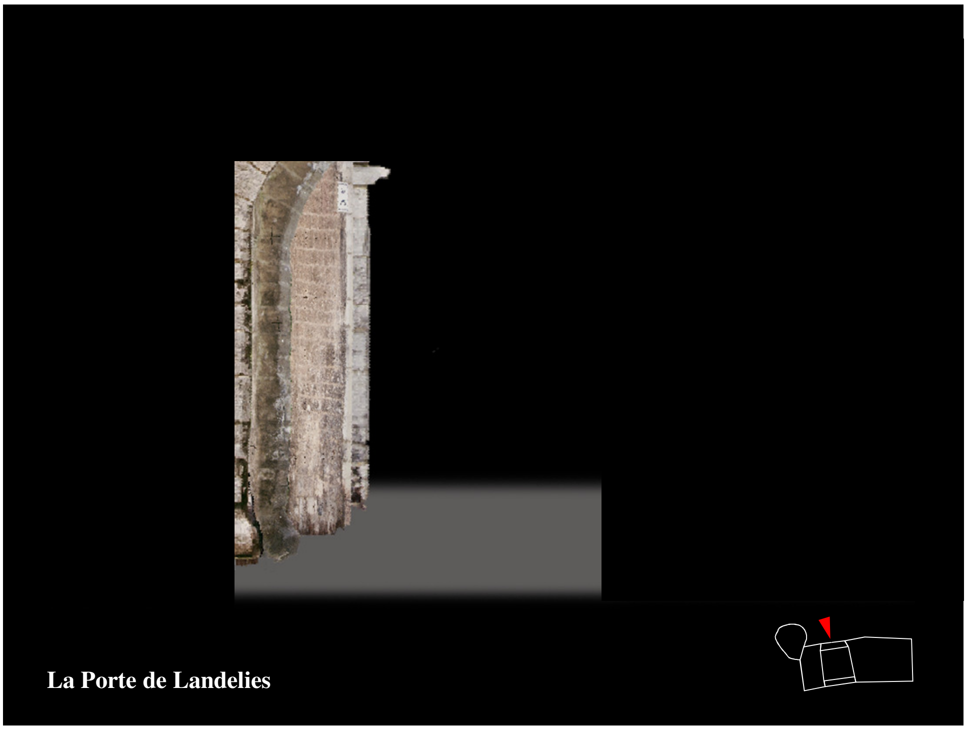
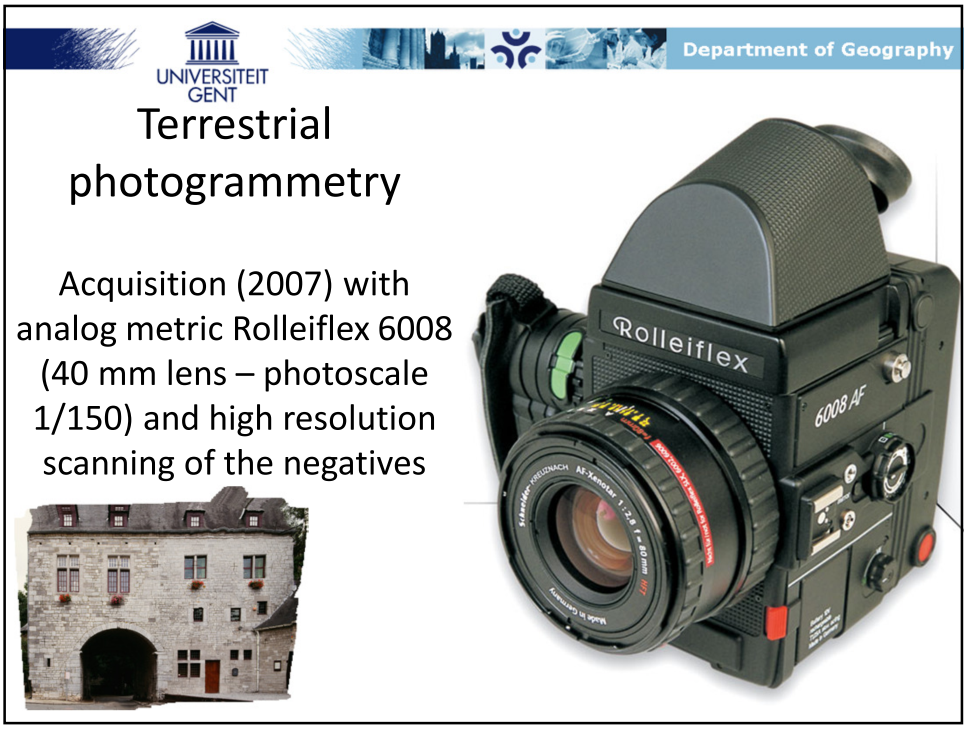
La Porte de Landelies


La Porte de Landelies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Terrestrial photogrammetry
Acquisition (2007) with analog metric Rolleiflex 6008 (40 mm lens – photoscale 1/150) and high resolution scanning of the negatives
Rolleiflex
6008 AF

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Photogrammetric restitution

End products:

- Orthophoto
- DTM generation
- 3D Model

General properties				
Scale	0.1458333		Pixel size (mm)	0.5
DEM spacing (mm)	10		Overlap	85%
GSD (mm)	5			

Otho Spacing distance

Relative orientation			
(rad)	Phi	Omega	Kappa
Left	-0.0022	-0.0136	-0.0556
Right	-0.0004	0	-0.0585
# points	130		
RMS (m)	0.004		

Absolute orientation			
# GCPs	x (mm)	y (mm)	z (mm)
7	6.218	9.049	25.915

DEM		
# points		10
Mean average Z (mm)		0.6
Mean square root (mm)		20.7
Error interval	# points	%
1.0 < dZ < 3.0	3	30%
4.0 < dZ < 5.0	1	10%
6.0 < dZ < 10.0	2	20%
10.0 < dZ < 20.0	0	0%
20.0 < dZ < 100.0	4	40%

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End result: orthophoto

Porte de Landelies at the *Abbaye d'Aulne*

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Methodology for the comparison of the TLS image (2011) and the orthophoto (2007)

1. Acquire the laser point cloud
2. Take a photograph from exactly the same point as the laserscanner
3. “Texture” or “Fit” both images to the point cloud (e.g. using Cyclone software)
4. “Normalise” the colors of both the “draped photo” and the photogrammetrically produced “orthophoto”.
5. Compute for every pixel the “color difference”
6. Select all pixels with significant “color difference”

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1. Acquisition of the Terrestrial laser scanning (with phase-based Leica HDS 6100)

Laser Scanner System	
Type	Phase-based
System Performance	
Accuracy of single measurement	
Position *	5 mm, 1 m to 25 m range; 9 mm to 50 m range
Angle (horizontal and vertical)	125 µrad/125 µrad, one sigma
Range	79 m ambiguity interval 79 m @90%; 50 m @18% albedo
Scan rate	Up to 508,000 points/sec, maximum instantaneous rate
Scan resolution	
Spot size	3 mm at exit (based on Gaussian definition) + 0.22 mrad divergence; 8 mm @25 m; 14 mm @50 m

* At 127.000 pts/sec scan rate, one sigma

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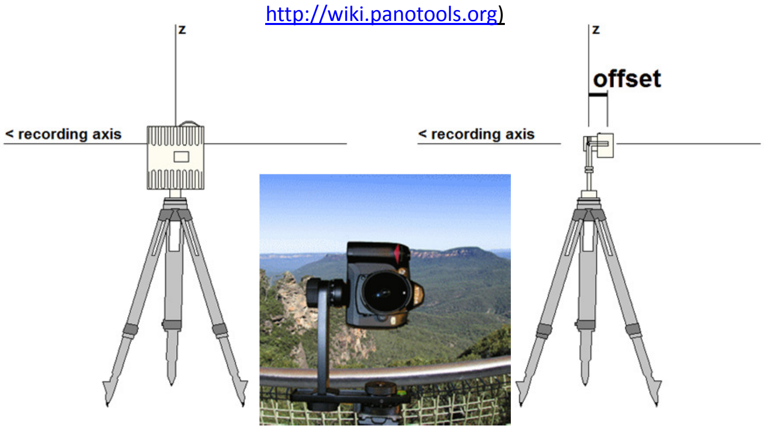
2. Photo acquisition

with DSLR Canon 450D (12 Mp) and Nodal Ninja 3II

Forced convergence of center of the scanner and ‘optical midpoint or point of no parallax’ of the camera, taking into account the offsets of the camera body and mounted lens (e.g. http://wiki.panotools.org)



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3. Point set texturing (Leica Cyclone software)

Intensity values, measured by the scanner

RGB values, based on image draping

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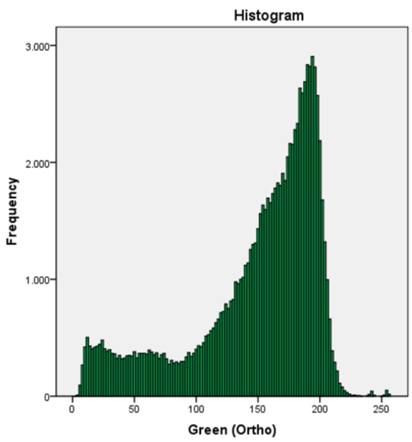
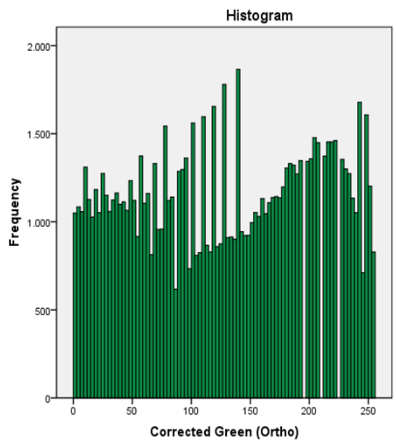
4. Color normalization (same mean and SD RGB intensities)





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4. Color normalization (same mean and SD RGB intensities)

Descriptives						
			Mean	St. Dev.	Median	EOM
TLS	Red	Original	132,56	40,533	143,00	0,129
		Corrected	128,59	74,007	128,20	0,236
	Greed	Original	130,13	42,485	141,00	0,136
		Corrected	128,53	73,982	129,55	0,236
	Blue	Original	122,51	42,112	132,00	0,134
		Corrected	128,50	73,952	129,09	0,236
Ortho	Red	Original	157,60	50,023	173,00	0,160
		Corrected	128,57	74,114	127,76	0,237
	Green	Original	147,66	51,948	164,00	0,166
		Corrected	128,52	74,062	127,76	0,236
	Blue	Original	140,31	52,617	157,00	0,168
		Corrected	128,42	74,093	129,34	0,237

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5. Compute local color distance between both sets by computation of "color cube distances"

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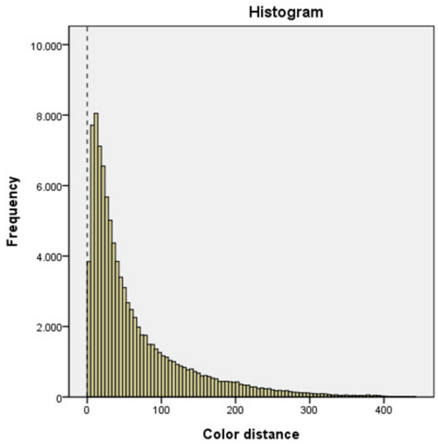

$LOG(\Delta(R,G,B))$

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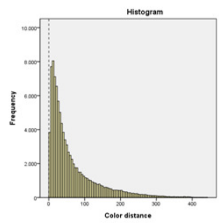
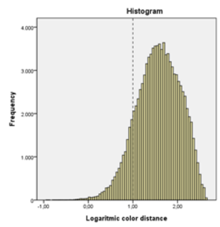
6. Select pixels with "significant color difference"

a. by applying t-test to log(distances) in color cube ?





One-Sample Test

	Test Value = 1					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper
Logarithmic color distance	366,609	98115	0.000	0.573	0.570	0.576

$LOG(\Delta(R,G,B))$

local differences for some RGB-value are significant

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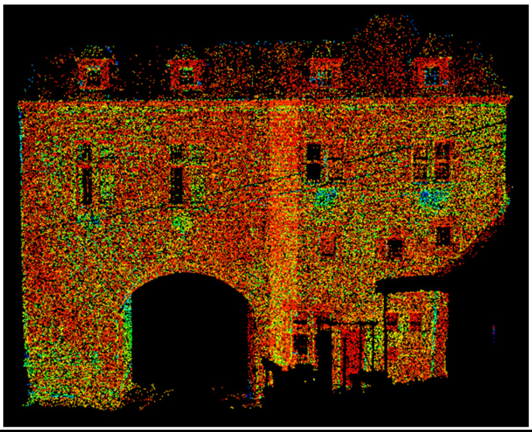
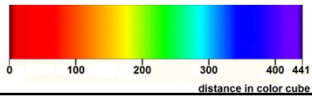
6. Select pixels with " significant color difference"

b. by "user-driven" color change trigger value (=> distance limit in color cube) ?



- Red+Yellow = Noise on the façade;
- Good radiometric matching of window frames and the door;
- Below the windows, clusters with high errors are visible: absence of flowers in image draped point set (2011).



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Conclusion

A methodology was given for comparing orthophotos resulting from photogrammetry with color-enriched laser scanning clouds

This methodology enables "change detection" based on a mathematical or user-driven "color change trigger value"

Draping images on a point set, acquired by TLS, seems to give results at least comparable in quality to conventional photogrammetry.

FIG Marrakech WW2011

FIG Working Week – Bridging the Gap Between Cultures
Marrakech, Morocco
May 18-22 2011
Under patronage of His Majesty King Mohammed VI

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Thank you for your attention

Questions ?

Contact & Information:
cornelis.stal@ugent.be
alain.dewulf@ugent.be

Ghent University, Department of Geography, Ghent (Belgium)
3D Data Acquisition Cluster

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