The use of different data sets in 3-D modelling

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Presentation outlines

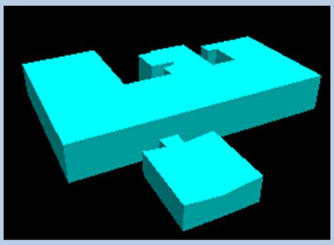
- Introduction
- Aims and objectives
- Test site and data
- Technology: Pictometry and UltraCamD
- Results and analysis of findings
- Conclusion

Introduction

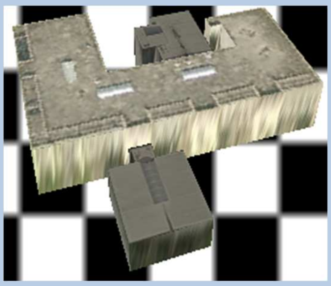
- Demand for 3D modelling of our environment is growing rapidly
- Some applications only need visualisation: planning, emergency response, decision making,……….
- Other applications need geometric correctness: Engineering applications, Cultural heritage documentation
- Creation of geometrically accurate 3D models is a costly Process
- Different data sets and methods need to be used

3D Urban modelling

3D model building has the following components:



- Accuracy:
  - Level of detail
  - Cost
  - Automation



- Geometry
  - Vertical images
  - LiDAR

- Texturing method
  - Terrestrial images
  - Vertical aerial images
  - Oblique aerial images

Aims and objectives

- The overall aim is to investigate the geometric potential of using the Pictometry images for 3D modelling and texturing.

This aim will be assessed through investigating the following objectives:

- Assessment of the images.

- Benefits in combining Pictometry imagery with UltraCamD images.

- Investigating the geometric quality of feature extraction.

- Assessment of 3D geometry of all buildings extracted using both photogrammetric systems: Pictometry and UltraCamD.

- Investigation into the quality of texturing the 3D models using vertical, oblique and combined blocks of both camera systems.

Test site and data

- The University of Nottingham, University Park Campus
- Pictometry images
  – 27 vertical images (nominally f = 65mm)
  – forward overlap 38% to 46%, side lap 25% to 36%
  – 57 oblique images (nominally f = 85mm)
  – forward overlap 21% to 47%, side lap 23% to 45%
  – GSD of 10-15cm
  – pixel size is 9μm
  – Nominal flying height is 1000m

Test site and data

- UltraCamD images
  - 86 images (nominally f = 100mm)
  - forward overlap 60%, side lap 30%
  - GSD 6cm - pixel size 9µm
  - Nominal flying height 500m

Pictometry Imagery

- Pictometry is a digital mapping process; it comprises:

- A five-camera system to capture a site of interest obliquely from the four cardinal points of the compass in addition to the traditional vertical view
- An image warehouse to store the imagery
- EFS (electronic field study ™) viewing software to work with Pictometry imagery
- An integrated system for position and orientation

Pictometry Imagery

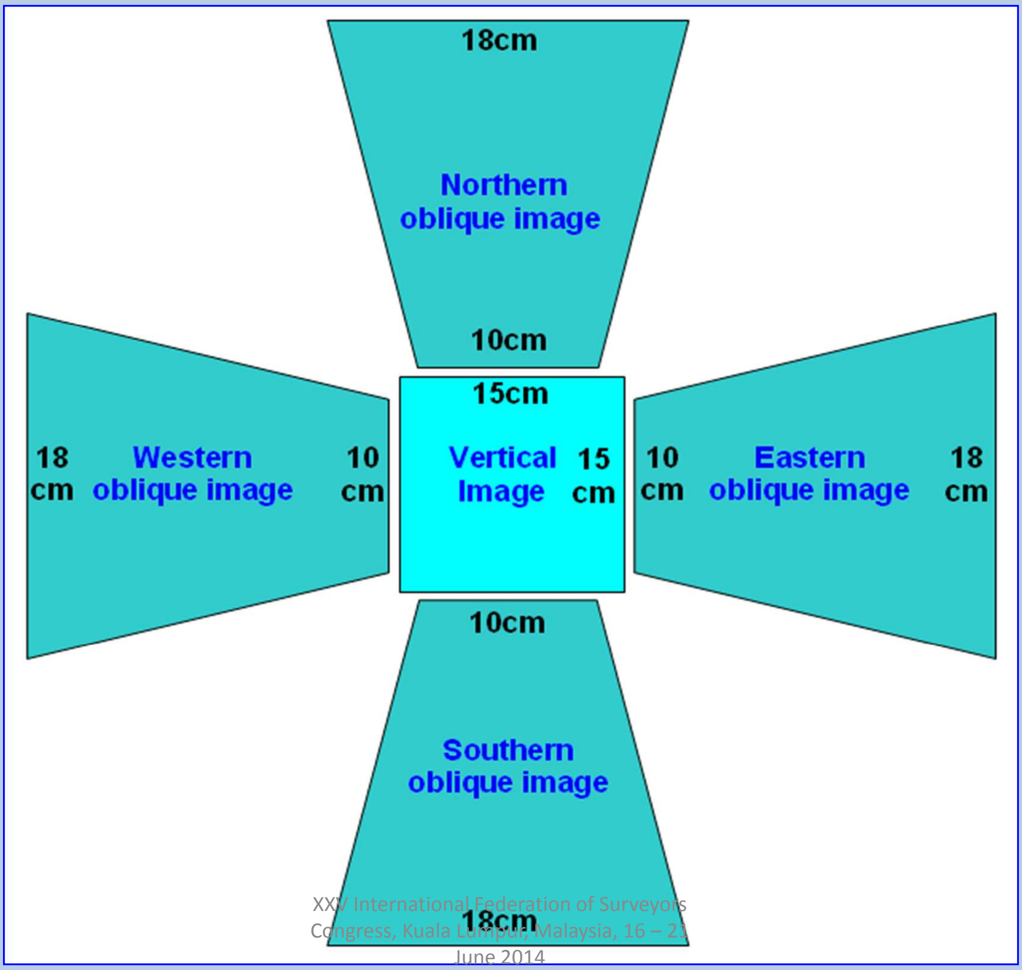
- Pictometry images consist of two types of images:
  - Orthogonal (traditional straight down) images (about 20% of images)
  - Oblique images: images taken at an angle between 45° and 60° (about 80% of images)

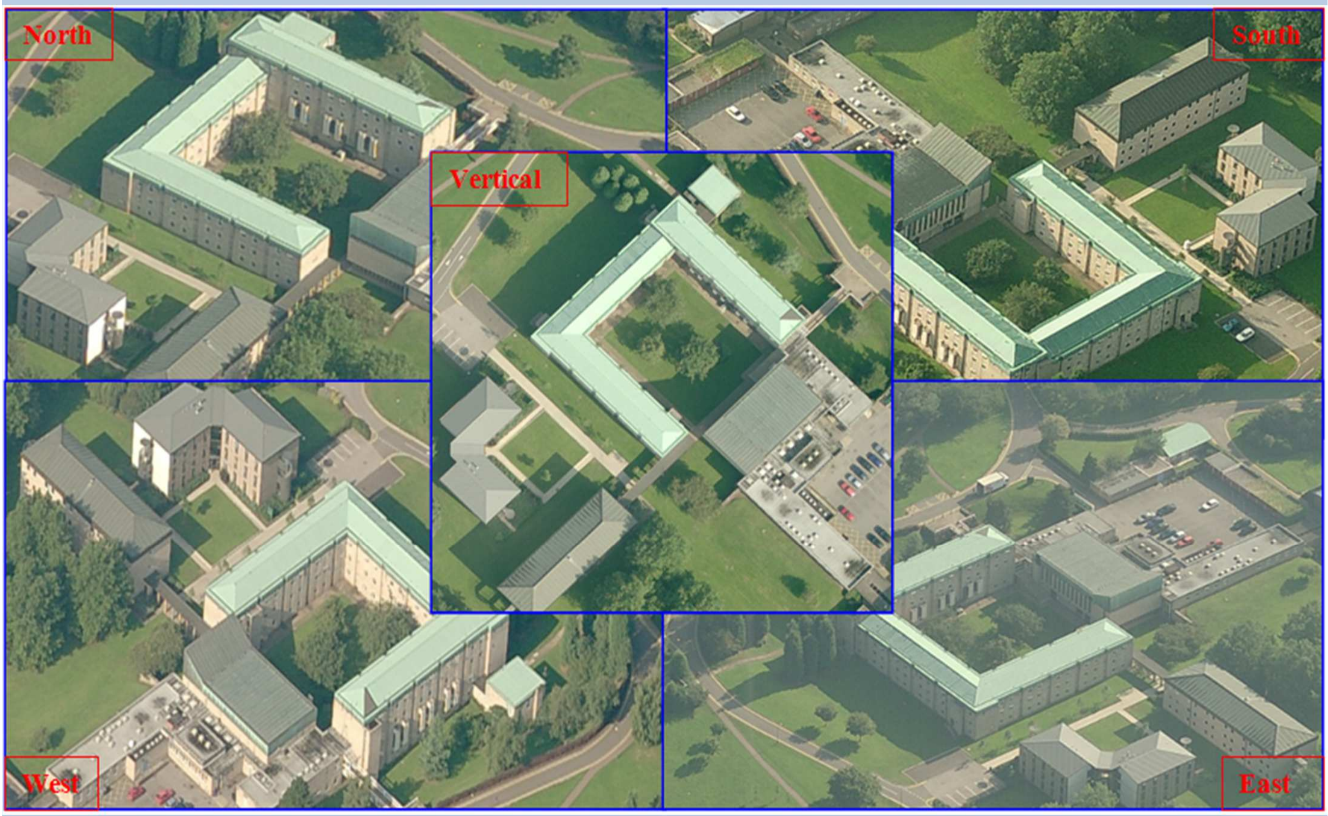
Pictometry Imagery

- Pictometry images are usually taken from two different levels: community and neighbourhood

  1- Community images
  - Flying height of 1500 to 1800m
  - Average resolution of about 60cm/pixel (45cm at front and 90cm at back of oblique image)

  2- Neighbourhood images
  - Flying height of 600 to 1000m
  - Average resolution of about 15cm/pixel (10cm at front and 18cm at back of oblique image)


18cm
Northern
oblique image
10cm
15cm
18
cm
Western
oblique image
10
cm
Vertical
Image
15
cm
10
cm
Eastern
oblique image
18
cm
10cm
Southern
oblique image
18cm


North
South
Vertical
West
East

Results: general

- All computations were performed using LPS
- Ground coordinated points (total 39)
  - observations performed manually to natural detail points
  - little more difficult to observe on the oblique due to tilt and scale differences
- Vertical Pictometry images: tie points automatically generated
- Oblique Pictometry images: manual measurement of tie points
- Tie points between vertical and oblique images were created through the ground control points

Results: general

- Four solutions have been considered;

Solution	Control			Additional parameters
	GPS	IMU	GCPs	
Float	**Large**	**Large**	**Small**	**with and without**
Constrained	**Realistic**	**Realistic**	**Small**	**with and without**
Integrated	**Realistic**	**Realistic**	**No**	**with and without**
DG solution	**Fixed**	**Fixed**	**No**	**with and without**
Small, Large and Realistic: Standard deviation value Small = high weight Large = small weight Realistic = actual estimated value				

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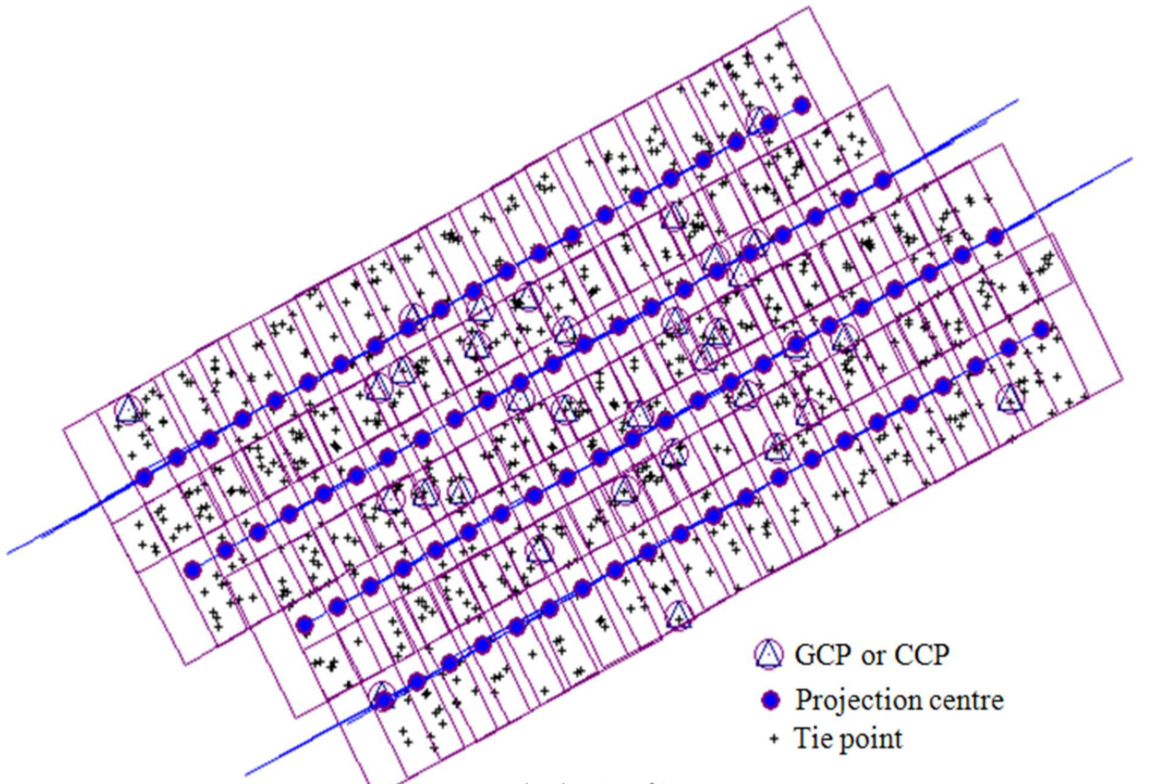
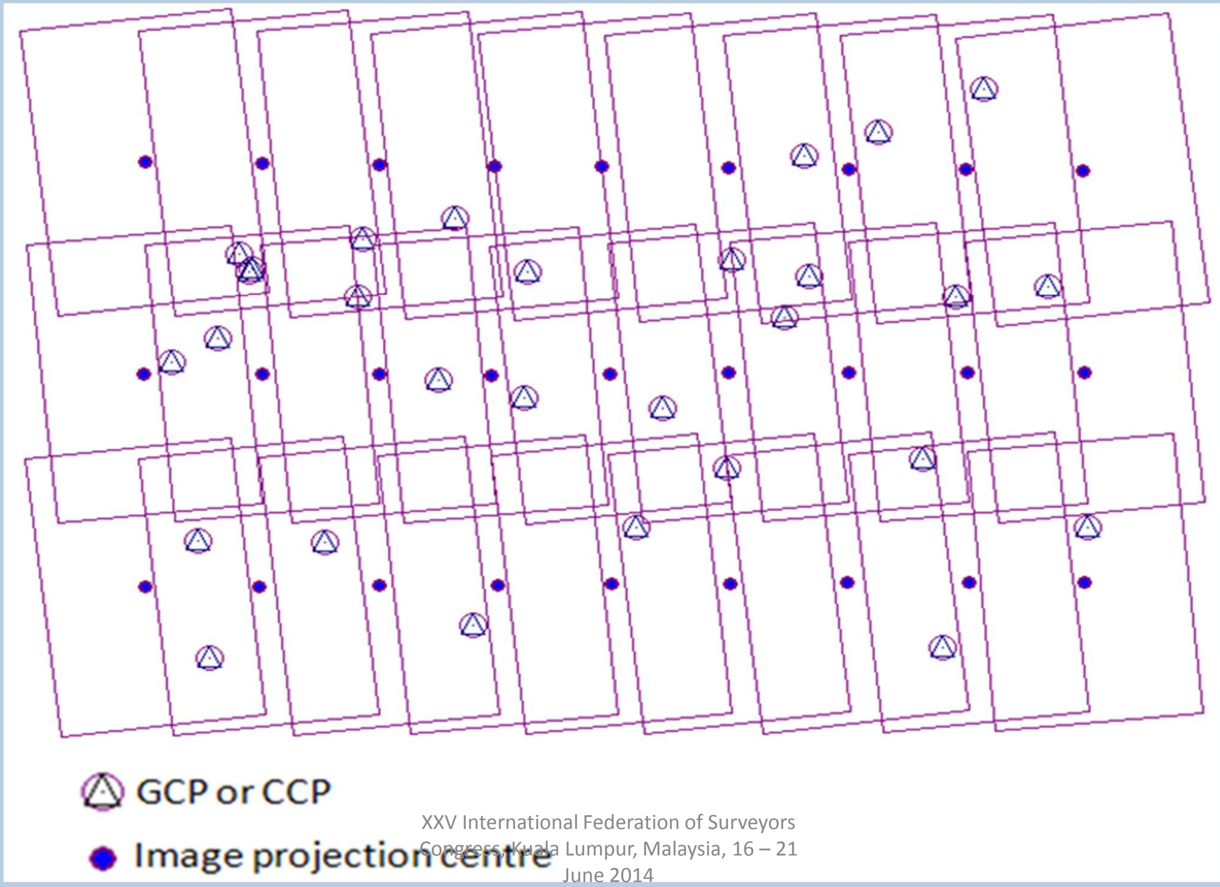
UltraCamD block results



UltraCamD block results

Solution		Float		Constrained		Integrated		DG	
AP		No	Yes	No	Yes	No	Yes	No	Yes
Total RMSE (µm)		3.0	2.9	3.1	2.9	3.1	3.0	5.2	4.9
GCPs RMS (no.pts)	X (m)	0.062 (9)	0.059 (9)	0.069 (9)	0.059 (9)	-	-	-	-
	Y (m)	0.068 (9)	0.055 (9)	0.056 (9)	0.043 (9)	-	-	-	-
	Z (m)	0.052 (9)	0.020 (9)	0.036 (9)	0.036 (9)	-	-	-	-
CCPs RMS (no.pts)	X (m)	0.062 (24)	0.043 (24)	0.067 (24)	0.048 (24)	0.069 (33)	0.058 (33)	0.090 (33)	0.089 (33)
	Y (m)	0.048 (24)	0.037 (24)	0.056 (24)	0.047 (24)	0.103 (33)	0.073 (33)	0.055 (33)	0.055 (33)
	Z (m)	0.118 (24)	0.089 (24)	0.107 (24)	0.109 (24)	0.105 (33)	0.096 (33)	0.123 (33)	0.102 (33)

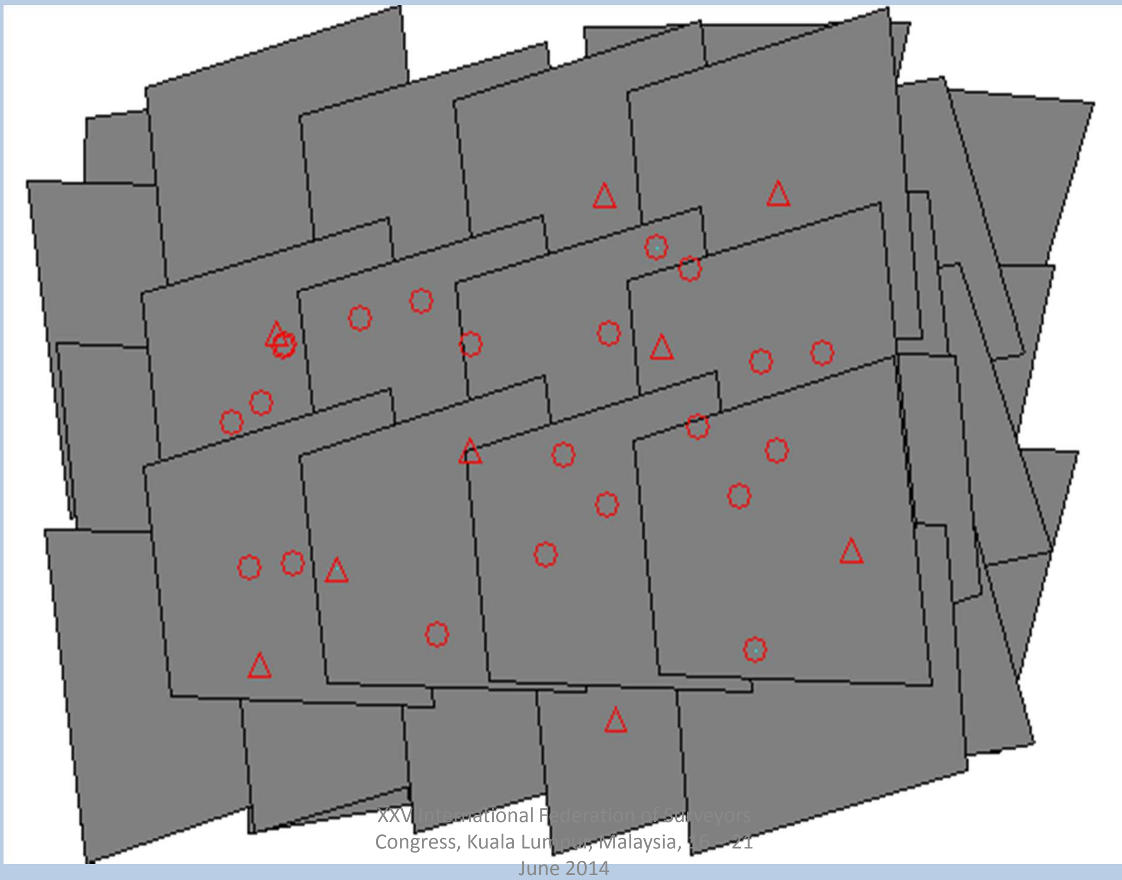
Vertical Pictometry images block



Vertical Pictometry images block

Solution		Float		Constrained		Integrated		DG	
AP		No	Yes	No	Yes	No	Yes	No	Yes
Total image RMSE(µm)		1.6	1.6	1.7	1.6	2.2	2.1	6.1	2.4
GCPs RMS (no.pts)	X(m)	0.025 (10)	0.024 (10)	0.029 (10)	0.025 (10)	-	-	-	-
	Y(m)	0.038 (10)	0.028 (10)	0.040 (10)	0.035 (10)	-	-	-	-
	Z(m)	0.009 (10)	0.006 (10)	0.011 (10)	0.011 (10)	-	-	-	-
CCPs RMS (no. pts)	X(m)	0.094 (19)	0.089 (19)	0.086 (19)	0.080 (19)	0.283 (29)	0.278 (29)	0.208 (26)	0.204 (26)
	Y(m)	0.082 (19)	0.076 (19)	0.077 (19)	0.071 (19)	0.447 (29)	0.458 (29)	0.552 (26)	0.460 (26)
	Z(m)	0.295 (19)	0.163 (19)	0.157 (19)	0.147 (19)	0.921 (29)	0.498 (29)	0.644 (26)	0.629 (26)

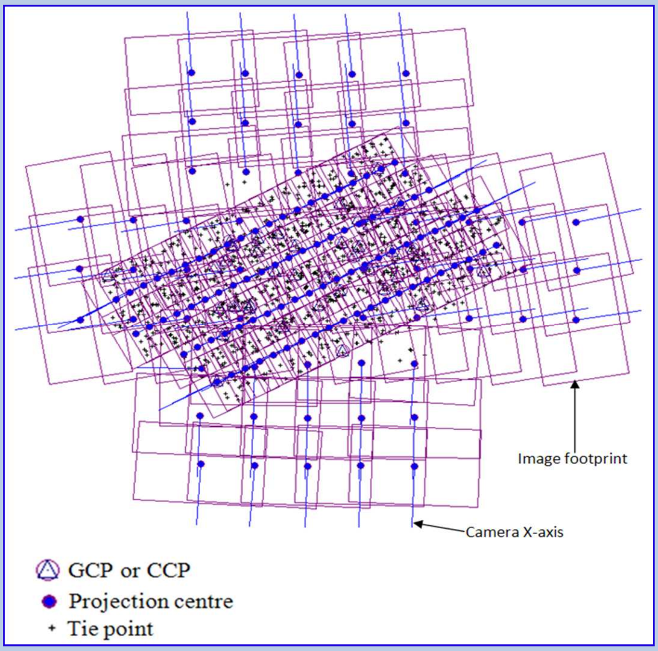
Oblique Pictometry images block

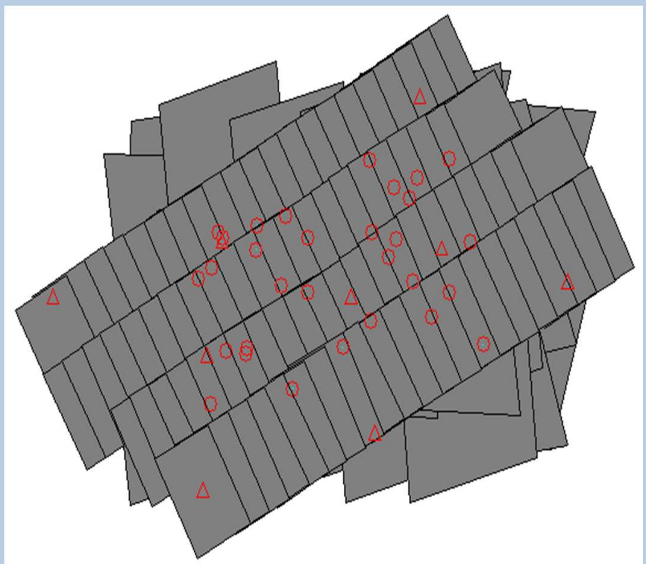


Oblique Pictometry images block

Solution		Float		Constrained		Integrated		DG	
AP		No	Yes	No	Yes	No	Yes	No	Yes
Total image RMSE(μm)		3.8	3.2	4.2	3.4	4.9	4.0	10.0	5.5
GCPs RMS (no.pts)	X(m)	0.030 (9)	0.021 (9)	0.056 (9)	0.025 (9)	-	-	-	-
	Y(m)	0.061 (9)	0.050 (9)	0.093 (9)	0.060 (9)	-	-	-	-
	Z(m)	0.066 (9)	0.027 (9)	0.053 (9)	0.023 (9)	-	-	-	-
CCPs RMS (no. pts)	X(m)	0.159 (22)	0.142 (22)	0.160 (22)	0.144 (22)	0.625 (31)	0.240 (31)	0.348 (31)	0.339 (31)
	Y(m)	0.187 (22)	0.181 (22)	0.192 (22)	0.172 (22)	0.398 (31)	0.169 (31)	2.957 (31)	2.282 (31)
	Z(m)	0.113 (22)	0.076 (22)	0.086 (22)	0.071 (22)	0.781 (31)	0.286 (31)	0.803 (31)	0.567 (31)

Combined UltraCamD and Pictometry imagery block





Combined UltraCamD and Pictometry imagery block

Solution		Float		Constrained		Integrated	
AP		No	Yes	No	Yes	No	Yes
Total RMSE(μm)		3.4	3.3	3.5	3.4	3.5	3.1
GCPs RMS (no.pts)	X(m)	0.074 (9)	0.080 (9)	0.087 (9)	0.092 (9)	-	-
	Y(m)	0.055 (9)	0.051 (9)	0.051 (9)	0.049 (9)	-	-
	Z(m)	0.052 (9)	0.035 (9)	0.056 (9)	0.030 (9)	-	-
CCPs RMS (no.pts)	X(m)	0.075 (30)	0.074 (30)	0.096 (30)	0.095 (30)	0.442 (39)	0.158 (39)
	Y(m)	0.076 (30)	0.072 (30)	0.083 (30)	0.081 (30)	0.226 (39)	0.198 (39)
	Z(m)	0.091 (30)	0.109 (30)	0.103 (30)	0.080 (30)	0.212 (39)	0.275 (39)

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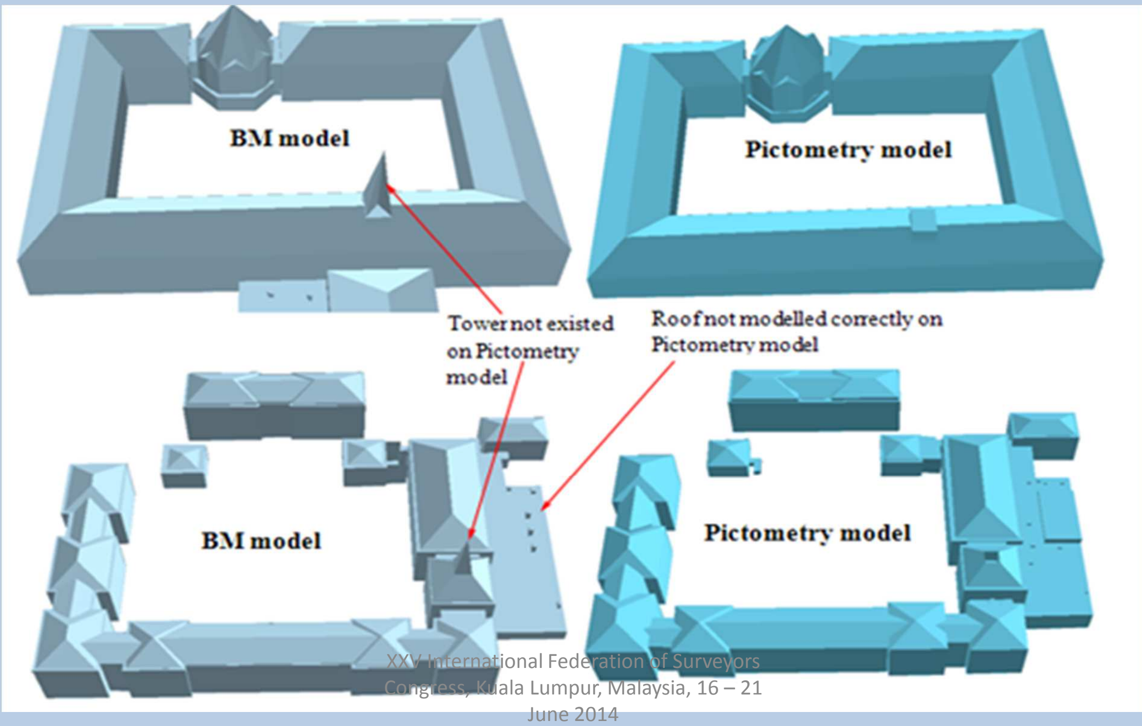
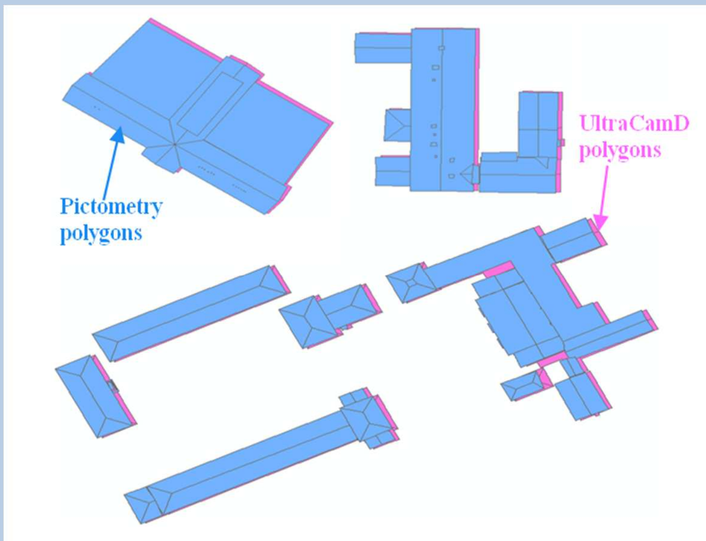
Modelling results

Accuracy of 3D models extracted from Pictometry imagery. (qualitative evaluation)



Modelling results

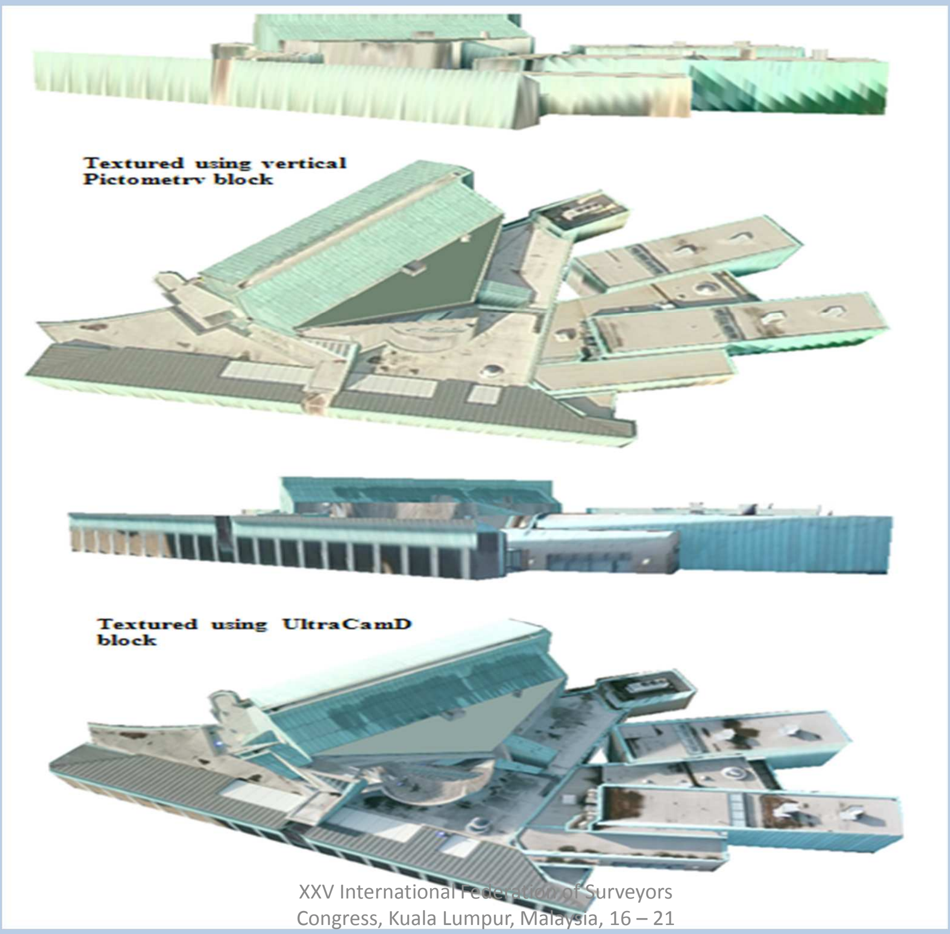
Quantitative evaluation: planimetric and height accuracy were compared with the BM models



Component	X	Y	Avg. Z
Min.	-0.960	-0.800	-2.380
Max.	0.582	0.590	2.300
St.dev.	0.286	0.187	0.952

Texturing results

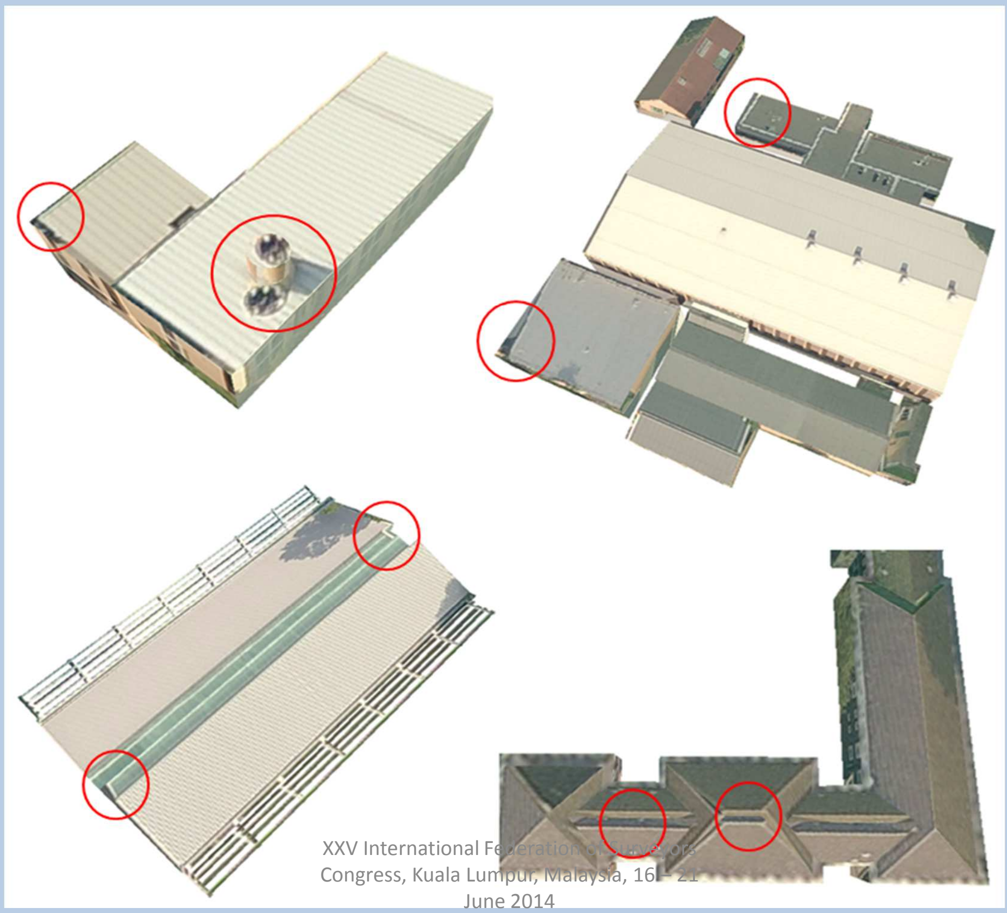
- Texturing of the 3D polygons was performed using: the vertical Pictometry block, oblique Pictometry block, UltraCamD block, a combined (vertical and oblique) Pictometry block, and combined UltraCamD and Pictometry block.
- The visual inspection of the textured models show that using either vertical Pictometry block or UltraCamD block has given very good roof structure
- when it comes to façade texturing the quality was not as good as roofs quality, the texture quality of the building facades is considerably degraded.



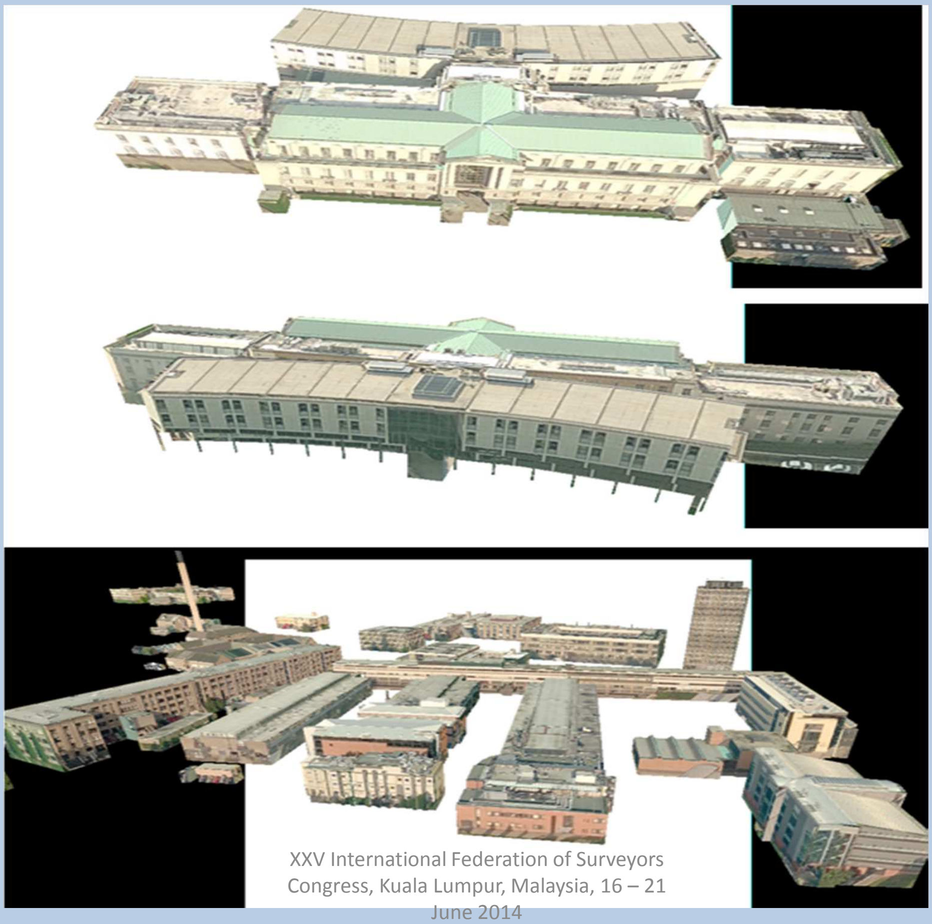
Texturing results

- When only the block of oblique images was used for texturing the 3D models, the façade texturing was of very good quality but the texturing quality of some buildings' roofs was reduced compared with the vertical images
- Combining both vertical and oblique images gives the benefit of good quality textures for both the roofs and facades

Texturing using oblique images block



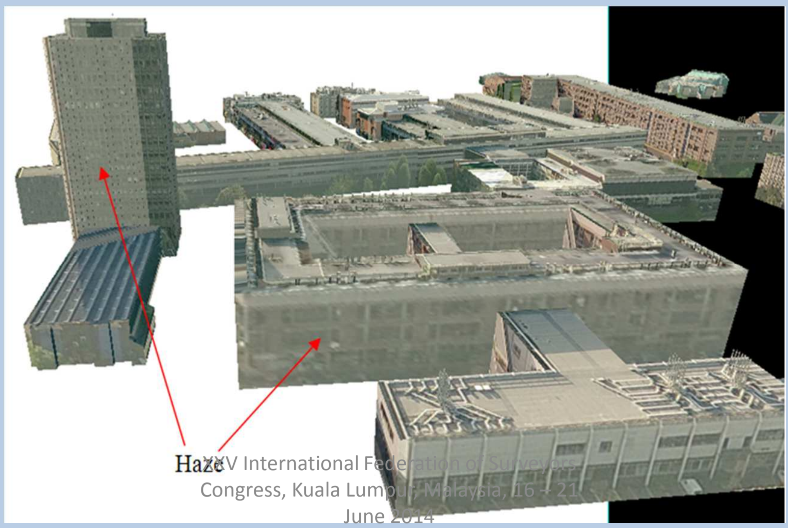
Texturing using combined UltraCamD and oblique images block



Analysis of texturing results

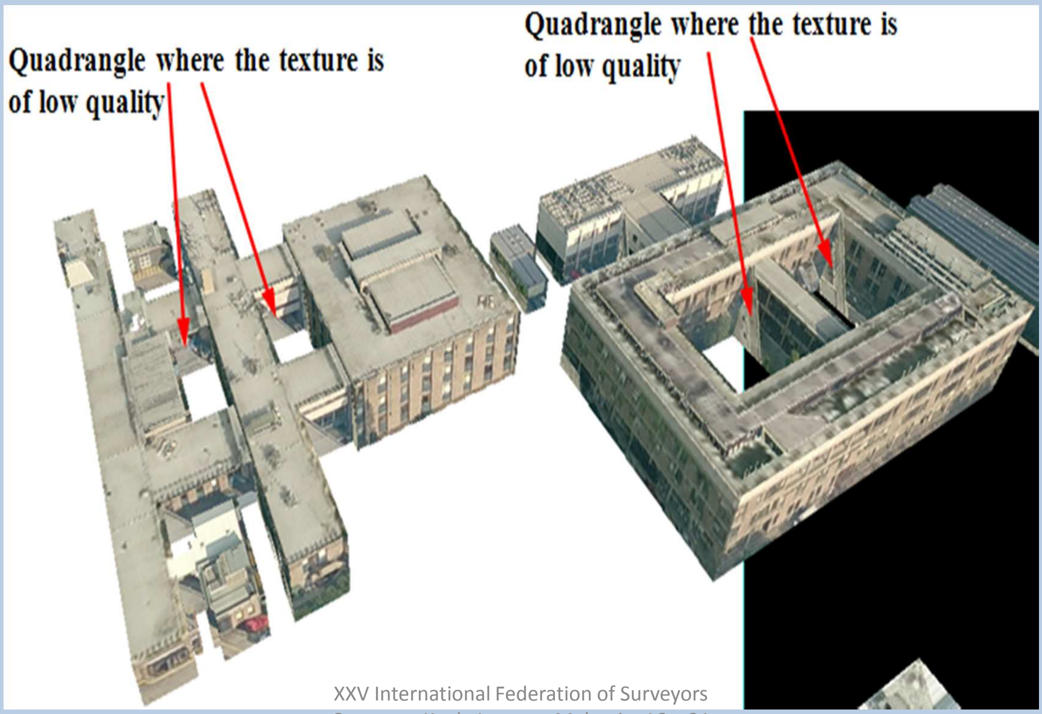
- some of the 3D models contain errors especially in terms of texturing

- The overall quality of the Pictometry images is characterized in some instances by the presence of haze which affects the texture mapping quality



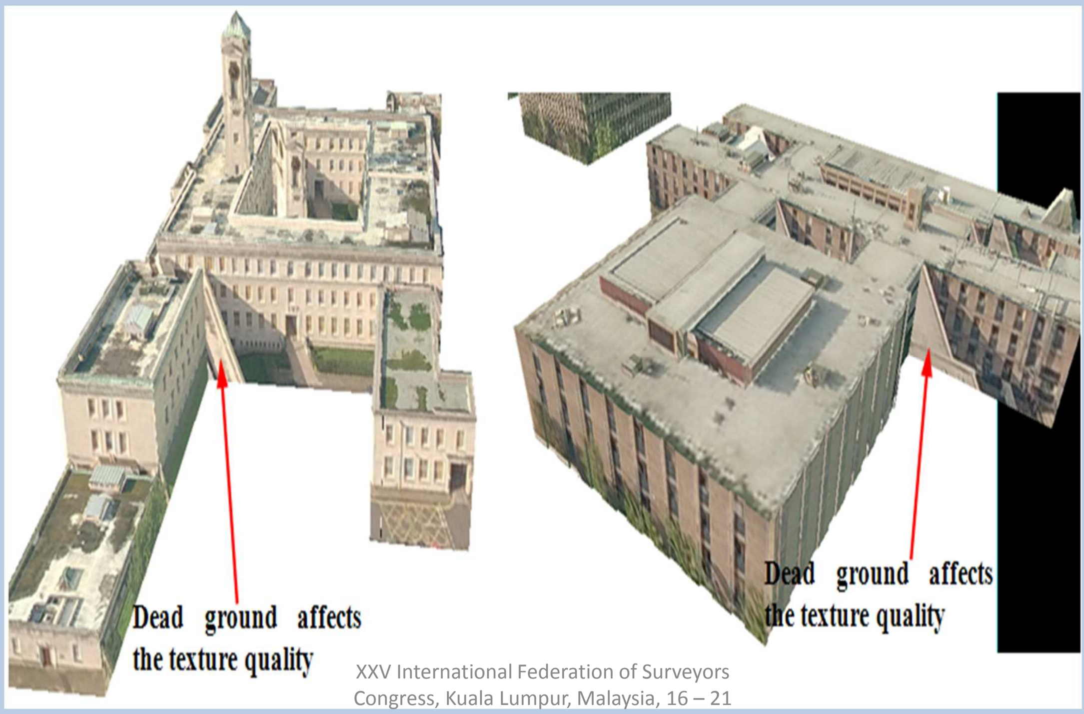
Analysis of texturing results

- Buildings with internal quadrangles are very challenging to texture from airborne images



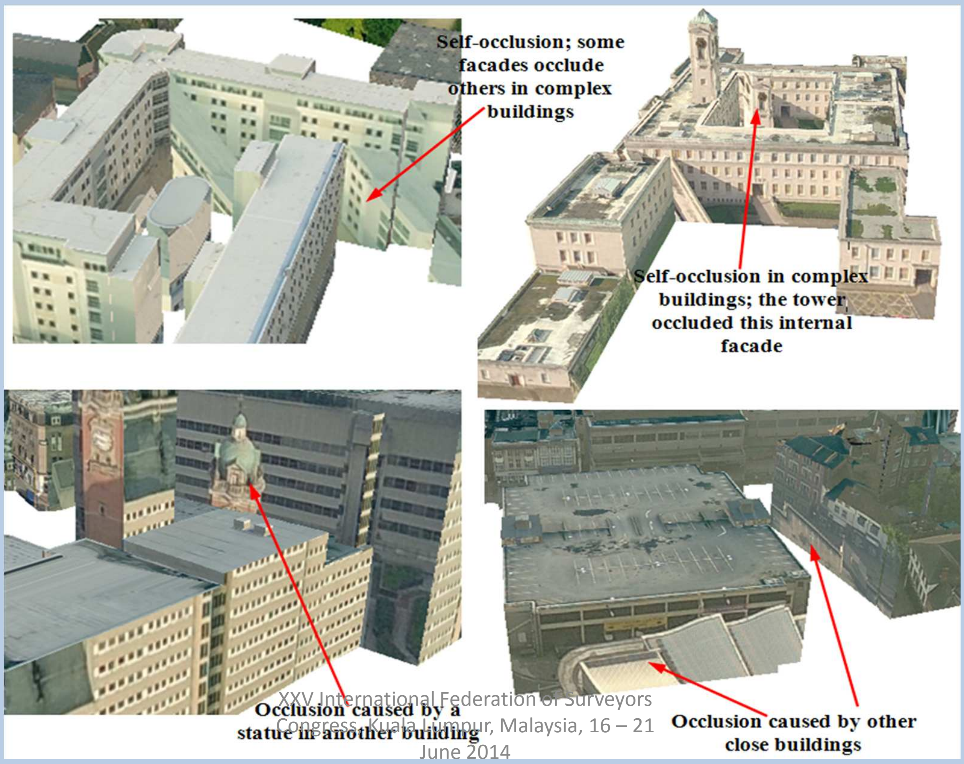
Analysis of texturing results

- The effect of dead ground; area that cannot be seen from the aerial images due to shadow or perspective view

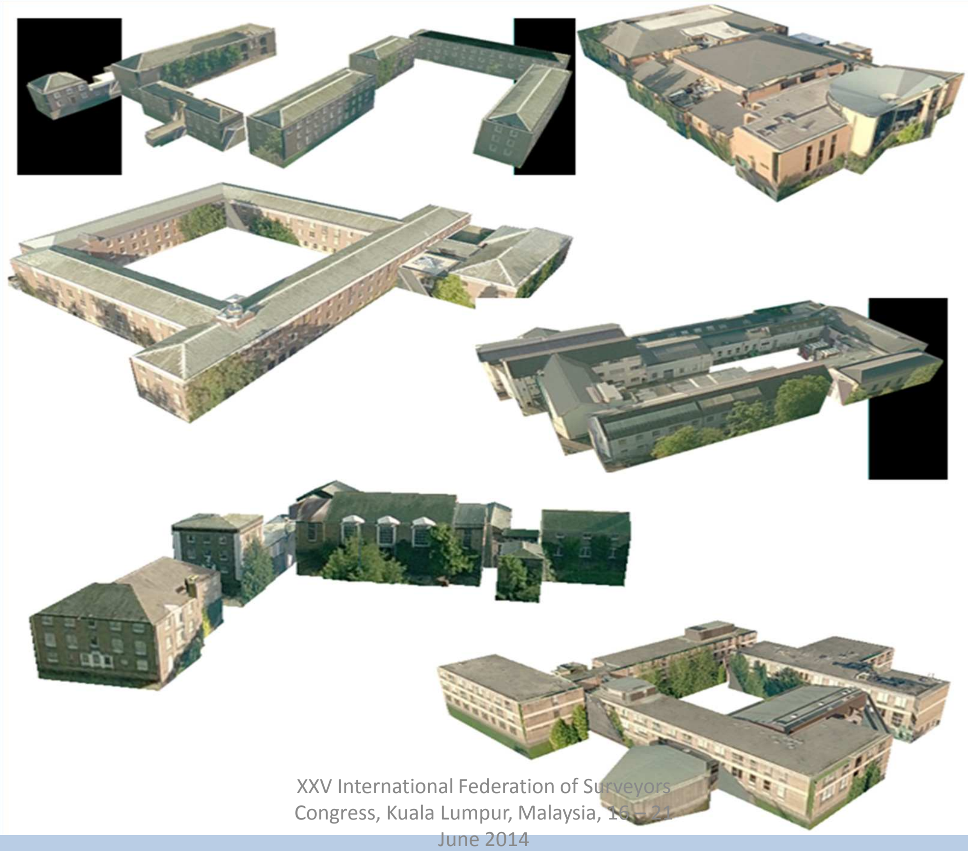


Analysis of texturing results

- The most important factor that affects the texturing quality is occlusion



Occlusion caused by vegetation and tall trees



CONCLUSION

- The use of combined blocks of vertical and oblique images in AT showed that good point coordination can be achieved.
- The results show that the revolutionary Pictometry oblique imagery can be used for texture mapping large models quickly and can enable photorealism.
- Terrestrial imagery might be combined with oblique imagery in certain areas to give better quality models, particularly when ‘ground level’ viewing of the models is required.

Acknowledgement

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