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„Integration of TLS and photogrammetric data based on selected object – Węgrzce Fortress”

Introduction

The main goal of the study was the integration of TLS and photogrammetric data based on Fort 47a „Węgrzce”. A comparison of both technologies and a discussion of the functionality of two softwares implementing SFM (Bentley ContextCapture and Agisoft Photoscan) were also carried out.

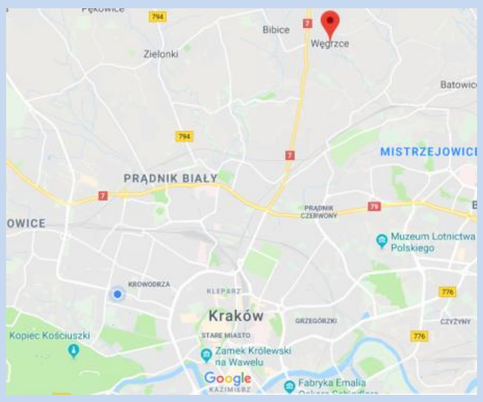

Fig.1. Location of Fort Węgrzce (source; Google Maps).

Fig.2. Fort Węgrzce (UAV image).

Fort 47a „Węgrzce” belongs to Kraków Fortress, founded on the initiative of the Austrians to defend the city against the Russian invader. It was erected in 1892-1896.

Bentley ContextCapture vs Agisoft Photoscan

The tests were carried out on the same set of photos. For the generated clouds, the following evaluation criteria were adopted: time of generating point clouds for different qualities, number of points in clouds, clouds density. Mesh models were evaluated visually and by number of vertices.

Table 1. Selected differences between softwares.

Bentley ContextCapture	Agisoft Photoscan
- importing video files and extracting individual frames, - no scripts (only in the ContextCapture Center version), - consists of two components: ContextCapture Master and ContextCapture Engine, which allows you to perform tasks on several computers (network processing)	- models only from static photos, - the ability to execute Python scripts, - greater flexibility in manipulating the scope of the study

Table 2. Characteristics of point clouds - ContextCapture.

quality	file size[GB]	number of points
medium	2,14	88 653 530
high	2,06	85 320 508
highest	2,06	85 248 177
ultra	2,74	86 762 801

Table 3. Characteristics of point clouds – Photoscan.

quality	file size[MB]	number of points
lowest	3,78	152 522
low	15,60	632 454
medium	63,40	2 558 715
high	226,00	9 135 228

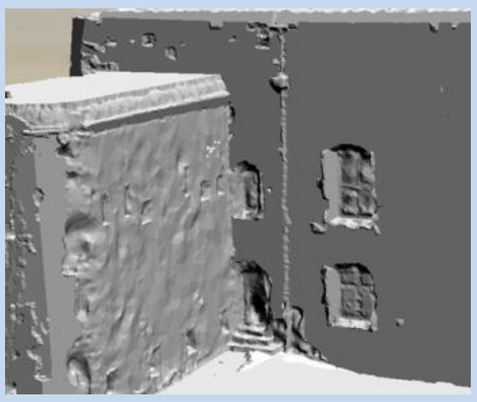

Fig. 5. Planar simplification – ContextCapture.

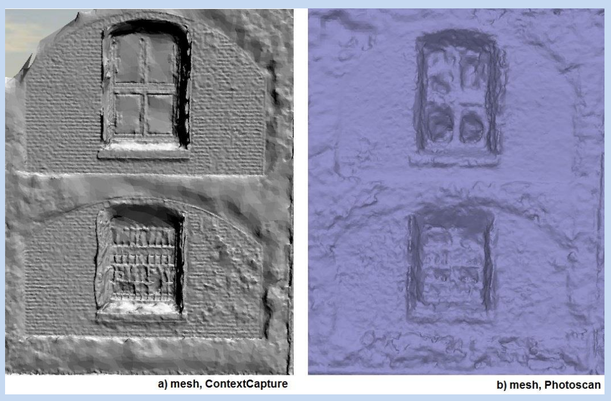

Fig. 6. The results for the highest possible settings.

Laser scanning and SFM - comparison

Some parts of the facade of the object have flat surface, which significantly reduced the efficiency of reconstruction from photographs (Fig. 9.). However, image matching allows to reproduce the edges better than TLS (Fig. 8.).

Table. 4. Selected features of TLS and SFM technology.

TLS	SFM (UAV)
- very high cost of equipment - independent of lighting - need to use reference spheres or checkboards	- low equipment costs - faster measurement of large objects - no need to use reference targets

Fig. 7. Registration of edges by TLS.

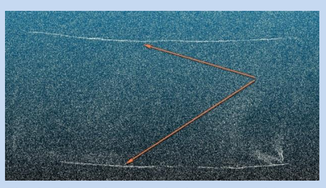

Fig. 8. Edges detection by image matching.

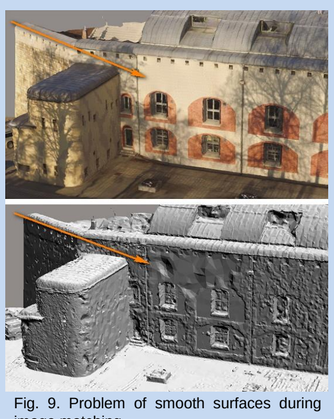

Fig. 9. Problem of smooth surfaces during image matching.

Data

Measurements included terrestrial laser scanning and UAV flight, which resulted in TLS dense point clouds and RGB digital photos. The Z+F IMAGER® 5010 laser scanner and the Phantom 3 Professional unmanned aerial vehicle with the DJI FC300X on-board camera were used (Fig. 3.). The integration of point clouds was carried out in the Faro Scene software (Fig. 4.)

Fig. 3. Z+F IMAGER® 5010 and Phantom 3 Professional (sources; *http://www.zf-laser.com/Z-F-IMAGER-R-5010.3d_laserscanner0.0.html?&L=1* , *http://www.dji.com/phantom-3-pro*)

Fig.4. TLS point cloud, Faro Scene.

Data integration and 3D modeling

Data integration was carried out on the fragment of the Fort Węgrzce. The integration consisted in creating a full surface model of the caponier, a protruding part of the barracks (Fig. 10.).
TLS point cloud and point cloud generated from photos (covering the whole area and the upper parts) were used.
The first two stages shown in the diagram below were performed in the CloudCompare software, next steps in Geomagic Wrap (3DSystems, USA).

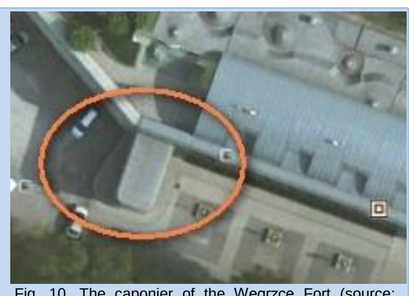

Fig. 10. The caponier of the Węgrzce Fort (source; Google Maps).

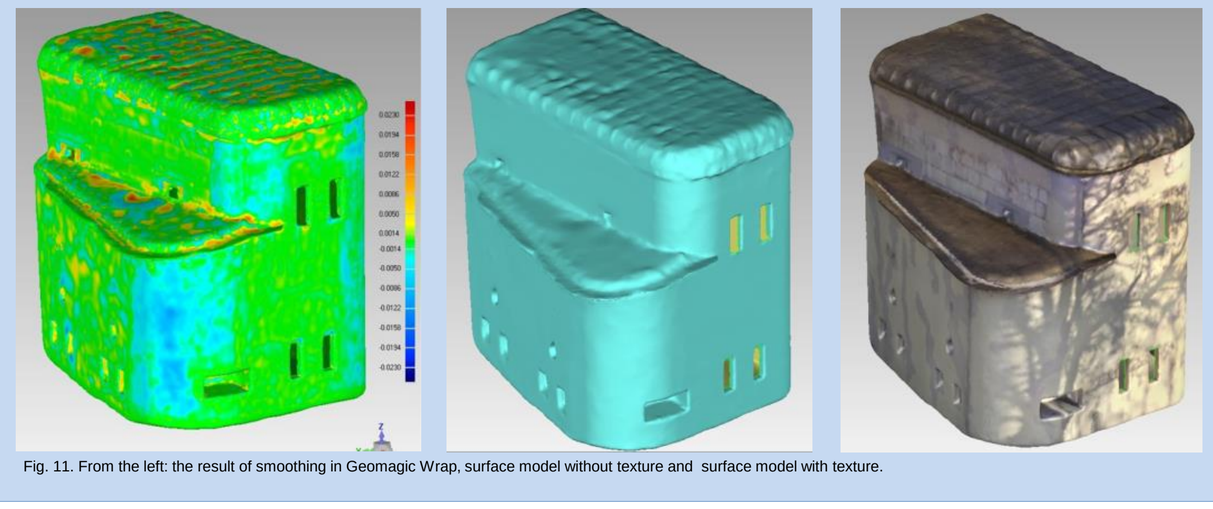

Fig. 11. From the left: the result of smoothing in Geomagic Wrap, surface model without texture and surface model with texture.

Summary

Both programs offer advanced tools for high-quality 3D reconstruction. In some aspects ContextCapture dominates, but in others - Photoscan. It is therefore difficult to identify the better of the discussed programs.
The comparison of measurement technologies has not been exhausted, it is a complex problem that can be considered more widely. The section „Laser scanning and SFM - comparison” shows some features of both technologies.
The integration of different types of data is very helpful solution if you can not register the object with a single sensor or when the accuracy of the study should be increased.

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