

DOCUMENTATION OF CORPUS CHRISTI CHAPEL IN KUTNA HORA BY LASER SCANNING TECHNOLOGY

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Abstract:

Laser scanning technology proves to be suitable in many applications. By its universality it may be used for mapping small objects (terrestrial LS) as well as large landscapes (aerial LS). LS technology in its terrestrial form was used for document the chapel of Corpus Christi located near the well known St. Barbara's cathedral in Kutna Hora. After decades of dilapidation, this historical monument from 14th century was reconstructed during years 1997-2000. The gothic vaults in the chapel were inappropriate for photogrammetric documentation because of colour homogeneity, which was no problem for active methods like LS. It is also very time consuming for classic geodetic methods to map the form of the vaults, therefore laser scanning technology was a perfect solution for mapping this object in detail. Detailed mapping of the chapel by LS technology took about 3-4 hours. The chapel area is divided by four pillars; this made it necessary to measure from nine different positions. Individual scans were later connected and a very detailed 3D model of the chapel was created by using software Geomagic Studio 8, which enables different outputs, e.g. 3D model in TIN form, contour plan of the vaults, horizontal or vertical cross sections, etc. The results from LS were compared to earlier mapping by classic geodetic methods.

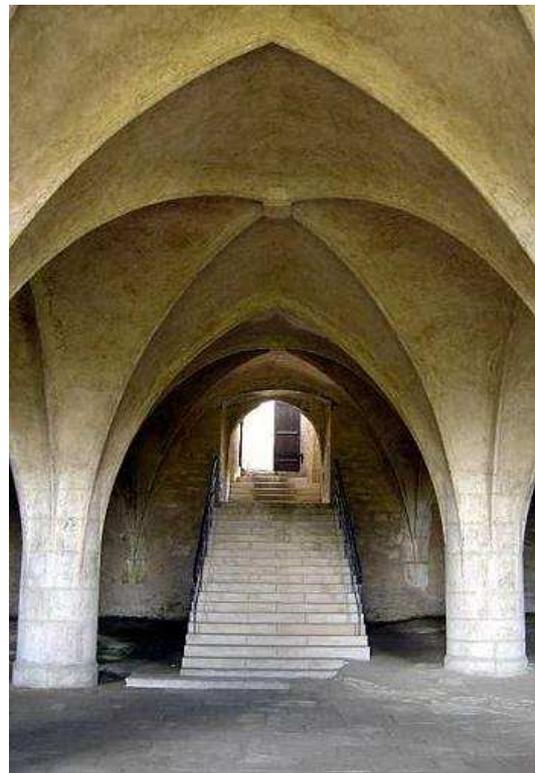
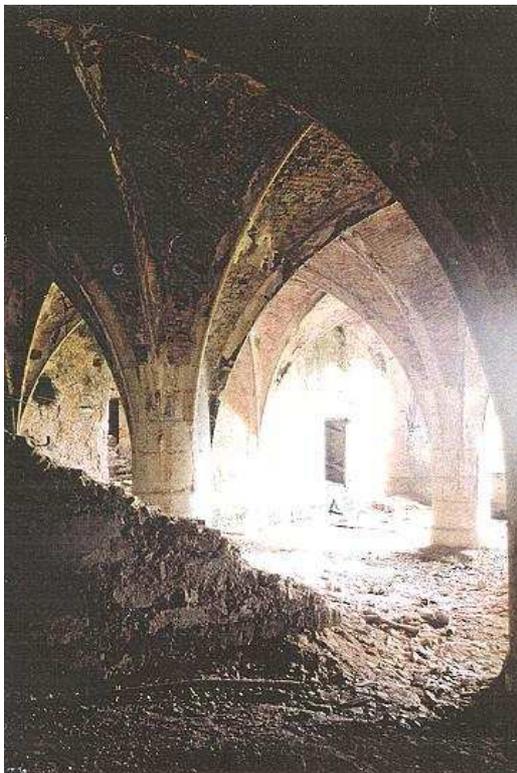


Figure 1: chapel condition - before and after reconstruction

1. HISTORY OF THE CHAPEL

History of the Corpus Christi chapel is closely associated with the history of Kutna Hora, the town well known through silver mining and its historical monuments. The cemetery chapel with an ossuary was built at the turn of 14th and 15th century in the immediate vicinity of St. Barbara's cathedral. The chapel remained in the original shape (gothic style, probably with a high roof) until the arrival of the Jesuits who, in connection with the construction of the Jesuit College, initiated a series of reconstructions and terrain modification resulting in a new entrance with a Baroque portal and a new roof. After the abolishment of the Jesuit order in the late 18th century, the chapel was transformed to serve as an groats mill and later as an organ workshop. From the mid 20th century the chapel began to decay. In the 1990's the chapel was put on the list of the 100 world's most endangered sites. Between years 1997 and 2000, the entire structure went through a total reconstruction and nowadays it is open to public and is used for small cultural events.

2. SURVEYING

To document the chapel, Callidus CP 3200, terrestrial laser scanner of German production, was used. The chapel interior is divided by four pillars into nine segments. Each segment is covered by cross vault, which complicates the survey. The object size is about 20x20m and the object was scanned from nine stations to ensure complete data coverage. Scan resolution was set to 0.25° in both directions (horizontal, vertical), which means a resolution of about 2cm at 4m distance. Mapping the chapel interior by laser scanning technology took 4 hours. Six control lengths were measured to verify the accuracy of LS method.

3. DATA PROCESSING

The data were processed using SW Geomagic Studio 8, which offers sufficient tools such as manual deleting, point cloud registration, or TIN generation. Data processing consisted of two phases: the point and polygon phases. The most important part of the point phase was the registration. The point clouds were joined to the central point cloud step by step according to the schema given below. Using the 'Manual registration' tool we identified about 4 identical points in two point clouds and transformed them approximately into the same coordinate system. Afterwards the 'Global registration' tool offered more precise calculation of transformation parameters from quite wide samples of point clouds. Correctly executed registration could strongly influence the accuracy of the final model. The setting of the 'Reduce noise' tool was fundamental for the detail and smoothness of the model (see fig. 3). The 'Compute Wrap' tool turned the point phase into the polygon phase; the entire model consists of 5 million triangles.

We created two versions of the model. The point clouds in the slower version were reduced - parts of the point clouds far away from the station were deleted and only a small overlap was kept. The slower version is the more precise because the point accuracy is increasing with the distance from observation station. In the faster version, the point clouds were kept without modification.

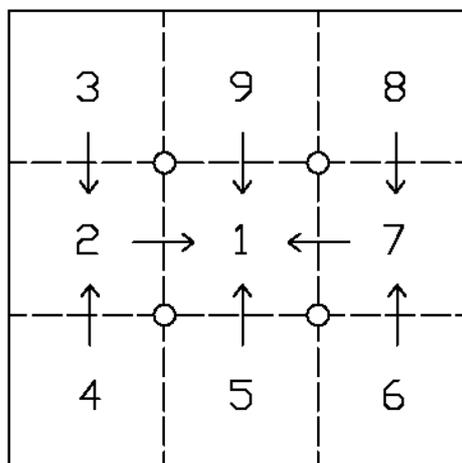


Figure 2: Schema - joining of individual scans

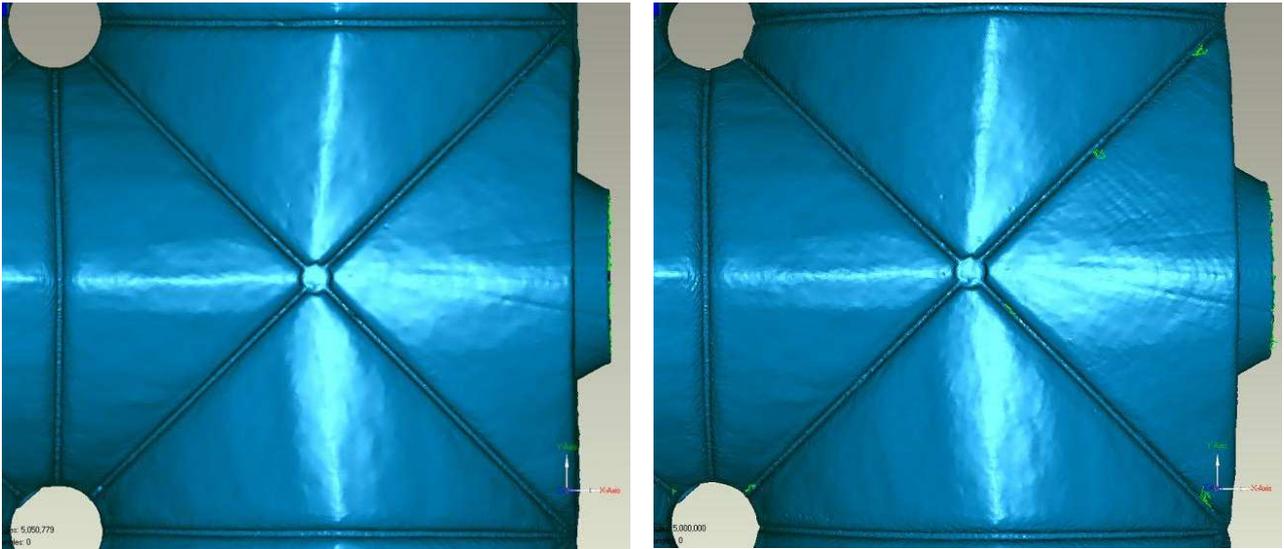


Figure 3: Slower (left) and faster (right) version - differences in detail

4. OUTPUTS

The main output from SW Geomagic Studio 8 is a model in .wrp form (compressed VRML). SW also enables generation of cross sections at different orientations and positions. Another possible output is a height image (using SW MatLab).

The accuracy of the entire model was verified by comparing six control lengths. The maximum difference between the measured distance and the distance from the model was 6cm. With respect to precision of the scanner and especially the number of connected point clouds and the transformation without ground control points, the differences between control lengths have expected values.

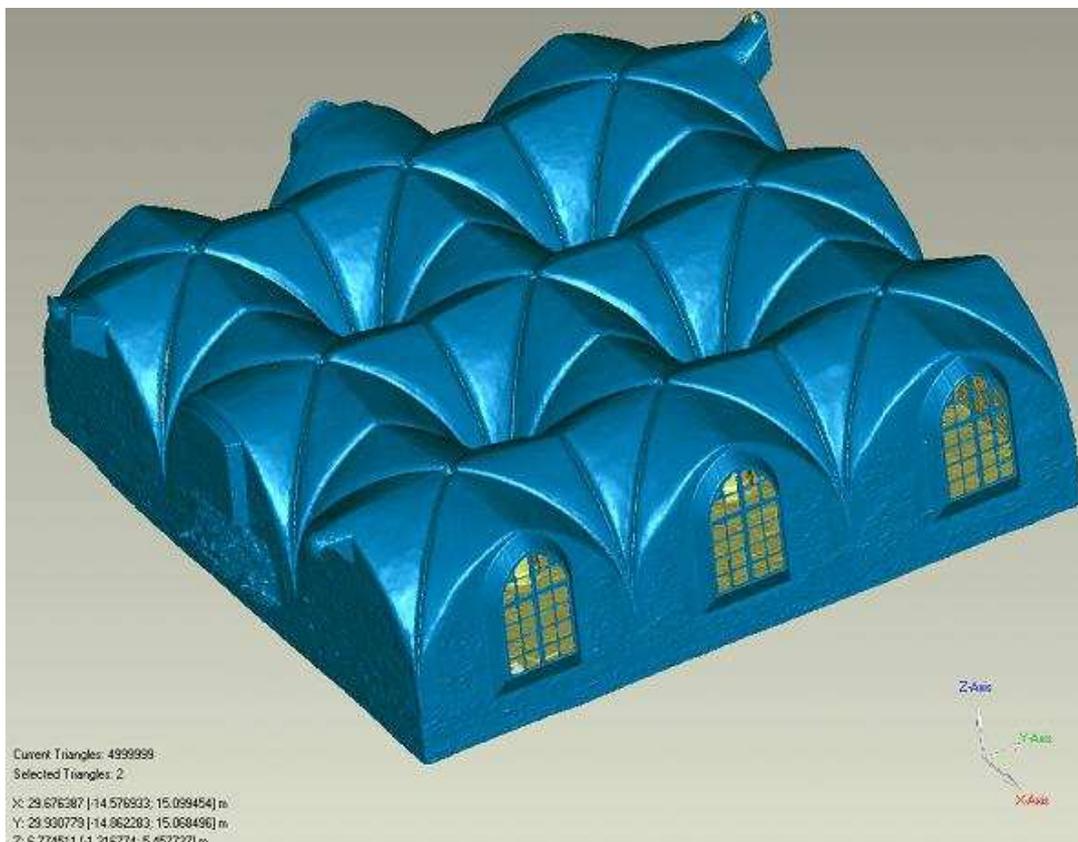


Figure 4: TIN model

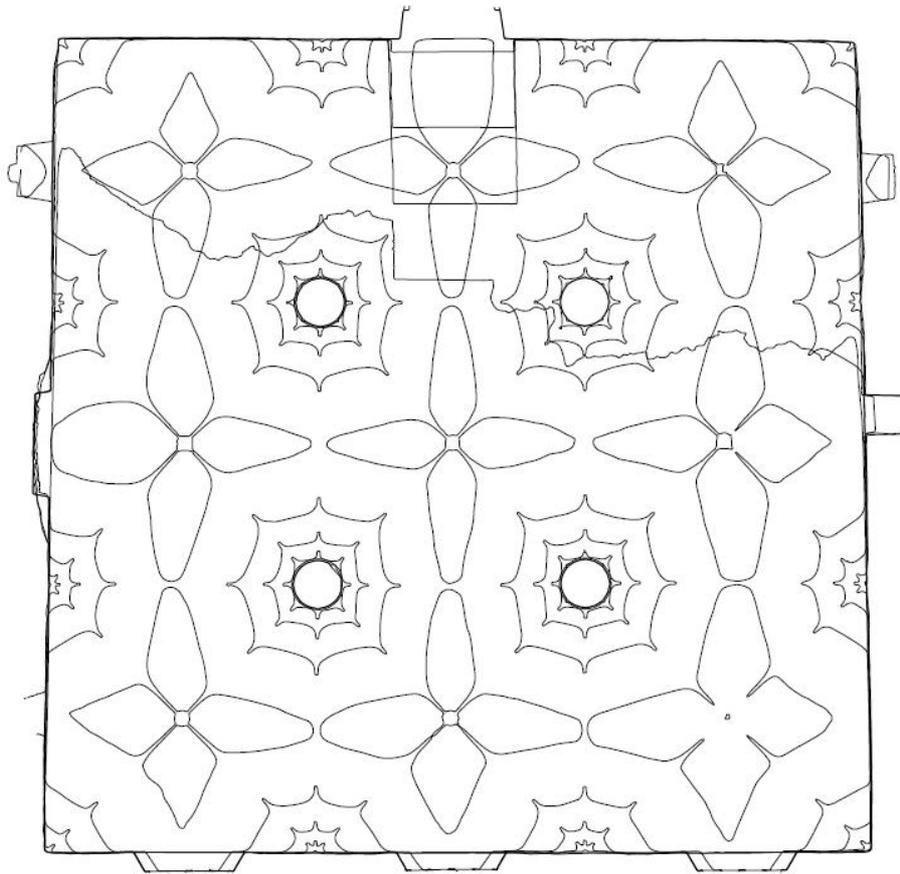


Figure 5: Horizontal cross sections

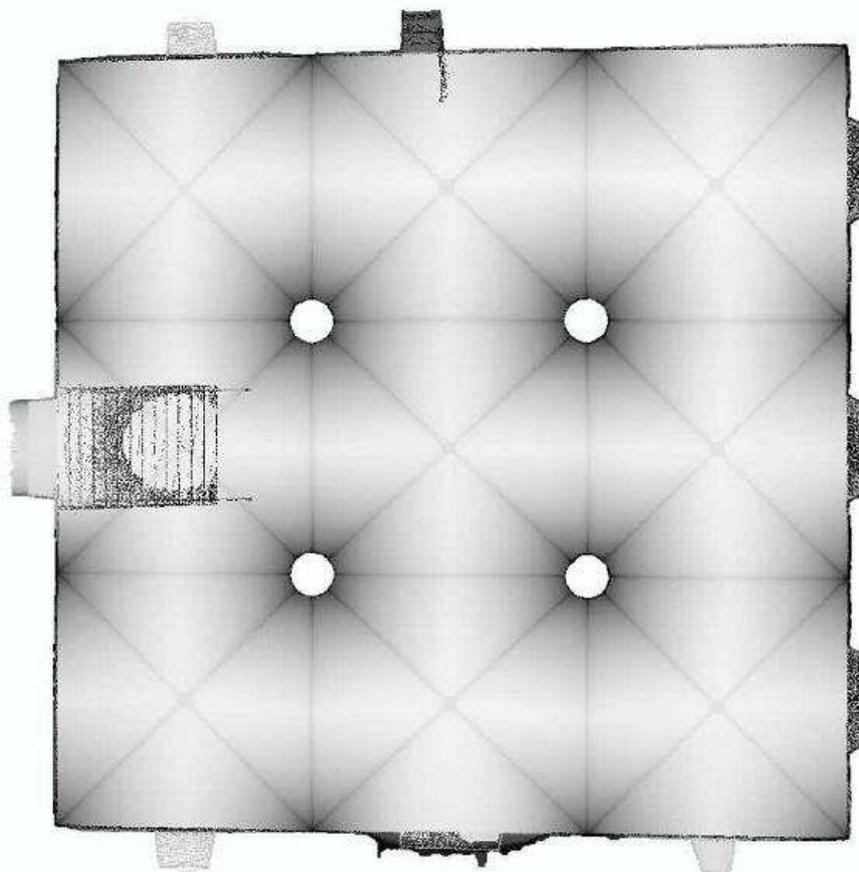


Figure 6: Height image

Length	m_{tape} [m]	$m_{\text{tape}\emptyset}$ [m]	m_{model} [m]	$\Delta = m_m - m_p$ [cm]
1	14.13	14.13	14.12	-0.01
	14.12			
2	16.21	16.22	16.19	-0.03
	16.23			
3	25.23	25.24	25.21	-0.03
	25.25			
4	26.60	26.59	26.53	-0.06
	26.58			
5	20.01	20.01	20.00	-0.01
	20.01			
6	19.97	19.97	19.93	-0.04
	19.96			

Table 1: Control lengths

5. CONCLUSION

Terrestrial laser scanning is an appropriate method for mapping objects which can be hardly approximated by geometrical primitives (i.e. using classical geodetic methods is unsuitable) or which are colour homogeneous (i.e. using photogrammetry is unsuitable). For mapping spatially complicated objects from more stations, it is appropriate to use ground control points to join the scans and ensure the highest possible accuracy.

REFERENCES

- [1] Zadrazilova, J. Kaple Boziho tela v Kutne Hore. *Zpravy pamatkove pece 7/1994*. Praha: JALNA, 1994. p. 228-229. ISSN 1210-5538.
- [2] Pavelka, K.; Hodac, J. *Fotogrammetrie 3: Digitalni metody a laserove skenovani*. Praha: Ceska technika - nakladatelstvi CVUT, 2008. 190 p. ISBN 978-80-01-03978-6.
- [3] Pavelka, K. *Laserove skenovani - nova technologie sberu prostorovych dat*. 2006, 32 p., CVUT v Praze, Fakulta stavebni. Inaugural lecture.
- [4] Callidus Precision Systems GmbH [online], [Retrieved 2008-05-10]. Available from Web: <<http://www.callidus.de/>>
- [5] Geomagic Studio 8. Manual on CD. Available from Web: <<http://www.geomagic.com/>>