A Point Cloud as the Starting Database for Reconstruction of Architectural and Constructional Documentation of Rural Cottage with the Use of CAD Programs

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Abstract. Modern rural buildings have usually simple form and uncomplicated layout of the rooms. And there is no decorative elements and architectural details. It is different in the case of historic buildings. Their design is usually quite complex and rich in detail. In order to carry out repairs or reconstruction of such a building it is necessary to perform the design and cost estimate on the basis of the existing facility. In the case of old buildings, this can be problematic due to the lack of documentation. Therefore, it is necessary to conduct an inventory of the object and restoring its technical documentation. 3D laser scanning is an accurate and relatively fast method. With the use of engineering software, building or even the entire habitat can be projected and drawn out in the form of any of the sections and views. In addition, the resulting three-dimensional object model can facilitate the distribution of the various functions associated with agricultural production and housing in the facility.

1. Introduction

Farmyard ancient buildings are valuable objects in a countryside landscape. A description and measurement taking of these objects can be conducted in different ways. Their outer measurements and situation may be determined on the basis of flights of unmanned flying objects [Baneszek et al. 2016]. Yet when there is a need of re-creation of the building documentation of a building, a more detailed measurement taking is required.

The technique of terrestrial 3D laser scanning provides a wide range of possibilities of practical use in an inventory of building objects. It is especially useful in collecting data of ancient monuments and of the type of construction used. As their plans and designs are often lost or unavailable, it is necessary to re-create them on the basis of research in situ. These kinds of buildings are characterised by rich ornaments which should also be measured and their technical documentation ought to be re-created [Antolak 2013]. Collecting data by a scanner is a more complicated process than measurements made with the aid of a telemeter or measuring tape. Though the results obtained are more accurate which makes it possible to prepare technical drawing of an entire object and all its details.

In this article, an especially detailed analysis of a dwelling house was made, which belonged to so-called Lithuanian farm in the open-air museum in Olsztynek. The measurement in situ were made by a ScanStation C10 scanner in the technique of terrestrial 3D laser scanning. The device makes a picture of an object thanks to a laser beam directed to the object, a procedure which provides three dimensional data saved in the point cloud format. Each point is described with the X,Y,Z coordinates as well as with the fourth coordinates which describes the intensity of reflection I [Szafranko,
Pawłowicz 2015]. The data obtained during camera work are the basis for preparation of an architectural-building documentation and for a detailed representation of elements of the building reviewed in a virtual space, which would sometimes prove difficult in the case of classical methods measurements. The CAD software is a tool which processes a point cloud after a removal of unnecessary elements. On its basis a draughtsman determines the course of walls’ edges and of the contours of a building. After their outlining we receive cross-sections and projections of an object together with precise dimensions. The building documentation obtained can be additionally enriched with three-dimensional visualizations in real colors.

2. Characteristics of the object researched - data collection and processing

The object under research is a peasant cottage built in ca. 1913, a part of a farmyard situated near Pempen in Lithuania. The very fact that the cottage was a splendid example of farmyard buildings from northeast Europe, it was moved as an exhibit to the open-air museum in Olsztynek near Olsztyn (Poland). It is a one-storyed building with a non-usable attic. Its walls are made from wood of the corner construction without protruding elements, with dove tail connections. The interior is seven-roomed with a so-called black kitchen and a smokeroom directly in two flues. All the rooms are provided with sunlight by windows. The doors are ornamented with reliefs and set in profiled door-jambs. The hip-roof is covered with a reed thatch. The rafter framing with collar beams is complicated in its top part with a fronton structure [Chodkowska i in. 2015].

A correct gathering of data in situ is related with the operational accuracy of a device. The minuteness of representation of each element depends strongly upon the density of a point cloud. The bigger density of the points, the more accurate picture is obtained and the better representation of details. The full information about the measured detail depends also on the situation of measuring places. They should be distributed in a such way which would enable to scan each side of an object [Rapp 2015].

During in-situ work a laser scanner not only places the object in a three-dimensional space but also takes pictures with an in-built digital camera. It provides the possibility of placing the photograph onto the scanned point cloud, thanks to which it acquires real colors, and as a result it is possible to browse the outcomes in the real geometry and colors (Figure 1).

![Figure 1. House elevation as a point cloud in real colors](image)

3. Preparation of architectural-building documentation

An architectural-building documentation is a basic source of information about a building. It is often a case that ancient monuments have no documentation of that kind or its content is incomplete or not in conformity to reality. A set of data obtained as a result of measurements in situ made with a 3D laser
scanner is a source of full information about the parameters of an object [Laskowski, Szulwic 2014, Mitka 2007].

As shown in the plan of the ground floor of the measured cottage (Figure 2), the point cloud in the form of grey glimmer seen at the picture and imported to the CAD program, was the basis for cataloguing all the rooms which were outlined and dimensioned.

After importing to an engineer program a point cloud is the basis for making precise drawings of projections or cross-sections of buildings in virtually any configuration. It is sufficient to set the section plane at a proper angle and the cross-section is to be seen. Thanks to the fact that a point cloud is three-dimensional, an object can be set in such a way to present the information optimally and most interestingly– which is shown in Figure 3a.

As it is shown on the example of a cross-section of the measured cottage (Figure 3b), the point cloud in the form of grey glimmer seen at the picture and imported to the CAD program, was the basis for cataloguing all the elements of the building which were outlined and dimensioned. Calculation of an area or cubature on the basis of a 3D picture of an object is quick and simple.

**Figure 2.** Ground floor plan prepared on a CAD program and based on a point cloud

**Figure 3.** Cross section of the cottage: a) view of the point cloud in axonometry, b) the view dimensioned in the CAD program
Drawings of a facade constitute also a part of an architectural documentation. They are views of a building with all the elements and details which are found on it. The face of a wall is always shown in an orthographic projection, which represents precisely the proportions of an object. Drawings of a facade are prepared in most cases with the aid of CAD programs, but it is better to represent them as a point cloud, since not only it reflects the original shape but also the original color and texture of a surface (see Figure 1).

4. Re-creation of documentation of construction elements
A technical documentation of a building is often supplemented with the information about the geometry and condition of its structure. The most interesting construction element of a peasant cottage is its rafter framing. Roofers, who constructed roofs of peasant cottages, often made them in an exceptional and unique style, characteristic for a given region.

The fact of making measurements with a 3D laser scanner of the interior of the object enabled to represent the construction of the roof. The process of selecting data and of separating only construction elements is relatively labour-intensive, but thanks to it, the entire rafter framing of the Lithuanian cottage was made (Figure 4). The structure of this wooden roof with its half-frontons is seen clearly as well as the smoke holes and the ridge. It can be also seen that it is a rafter-collar beam structure, additionally strengthened with lateral trusses.

Selection of data also enables to import a point cloud to a CAD program, which makes possible to make construction projections of a roof and its dimensioning (Figure 5).

5. Summary and conclusions
The 3D laser scanner is a useful device for making inventory drawings and for re-creating an architectural-building documentation. Drawings of projections, cross-sections or facade which are made with the aid of engineer programs are very precise. Thanks to the possibility of gathering data from a distance, the measurement work is safe because there is no need for a surveyor to use ladders or scaffoldings while recording details on a considerable altitude, which can cause an accident. A scanner feature which is also advantageous is the possibility of an attractive presentation of results (in the form of 3D visualisations or films), which can prove important when selling the work to an investor [Pawlucz, Szafranko 2016].
Figure 5. Creating a roof structure plan based on a point cloud

Digital data can be the basis for making a three-dimensional object and for its presentation in a virtual space. A digital model re-created with the aid of CNC devices and 3D printers will be a faithful copy of the existing model. The use of reversed engineering may help not only in archival documentation and information about an object, but also in preserving its three-dimensional image for descendants.

References
[1] Antolak M. (2013), Zróżnicowanie oraz przekształcenia detalu architektonicznego w wizualnym odbiorze zabudowy na przykładzie gminy wiejskiej Ostróda. Acta Scientiarum Polonorum, Administratio Locorum, 12 (3), 5-13,
[2] Banaszek A, Banaszek S., Żarnowski A. (2016); Wykonywanie lotów bezzastojowymi statkami powietrznymi na potrzeby pozyskiwania danych przestrzennych–ramy prawne; Acta Sci. Pol. Administratio Locorum 15 (2), 7-19,
[3] Chodkowska W., Sabljak-Olędzka M., Adamiec Z., (2015) Historia Ostpreuβisches Heimatmuseum w Królewcu, Muzeum Budownictwa Ludowego – Park Etnograficzny w Olsztynku, Olsztynek,
[4] Laskowski P., Szulwic J.,(2014) Royal Chapel in Gdańsk. Study of facility inventory with the usage of laser scanning within the frames of student project, ICERI2014 Proceedings. 7th International Conference of Education, Research and Innovation. 17-19 November, 2014. Seville, Spain, pp. 1698-1707. http://library.iated.org/view/LASKOWSKI2014ROY
[5] Mitka B., (2007) Możliwości zastosowanie naziemnych skanerów laserowych w procesie dokumentacji i modelowania obiektów zabytkowych, Archiwum Fotogrametrii, Kartografii i Teledetekcji, Volume 17b, 525-534;
[6] Pawłowicz J.A., Szafranko E., (2016) Application of reverse engineering in modelling of rural buildings of religious worship, Engineering For Rural Development, 15, 762-766
[7] Rapp P. (2015) Methodology and examples of revalorization of wooden structures in historic buildings. Wiadomosci Konserwatorskie – Journal of Heritage Conservation, 43:92-108
[8] Szafranko E., Pawłowicz J. A., (2015) Inventory of agricultural building objects based on data obtained from measurements by laser scanning.; Engineering for Rural Development, 20.-22.05.2015, Jelgava, Latvia, 190-194