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USE OF MODERN METHODS OF TERRESTRIAL LASER SCANNING ON PRESERVATION OF THE RELIGIOUS PATRIMONY IN ROMANIA

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Abstract

This article presents the results obtained by the three-dimensional study of the church Madona Dudu in Craiova, carried out by means of a terrestrial laser scanner. The church Madona Dudu from Craiova, is documentary attested in the year 1758, when on the place of the old wooden churches, dated by 1700, has been built another one higher, on stone (between the years 1750-1756), by the great clucer Constantin Fotescu and the tanner Ion Gheorghe Hagi. It was built in the brancovenian style, with abside for pews, having three spiers: one above the nave and two above the narthex. The survey was carried out by the Photogrammetry, Geodesy and Topography team, of the Faculty of the Agronomy from the University of Craiova. This work explores the use of laser scanning for 3D modelling and documenting historical monuments in the field of cultural heritage. In this case the churches and the generation of plans and cross-sections of this Romanian churches in the city of Craiova. The results of both the 3D model plans and sections are in accordance with the specifications and up the stairs representation commonly used in conventional measurements of historical monuments recommended in the specialized literature. The objective of this study shows the potential use in the territory of the laser scanner on documenting historical heritage by making 3D model by combining cloud of external and internal points and the generation of plans and sections of the Church Madona Dudu in Craiova.

Keywords: cultural patrimony, restoration, church, cloud, points

1. Introduction

Study of the cultural heritage is very important for the documentation of the natural, historical and tourist patrimony connecting the past and the future of any nation. There are many methods for the documentation of the cultural heritage, such as: manual measurements, topographical photogrammetric traditional methods, laser scanner terrestrial and using the drones.

In recent years, using the laser scan technology, photogrammetric thousand points on the surfaces of objects is obtained with an effort reduced in terms of

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time and cost compared with the three-dimensional measurements based on classical methods.

In this study, is presented the potential use of terrestrial laser scanner documentation of historical heritage, for both 3D modelling, in the clouds of points from the outside and inside of the facility, which are common as regards the generation of plans and sections of the Church Madona Dudu in Craiova.

The resolution of clouds of points was used to obtain various models according to the specific needs of each construction in hand, in the present case Madona Dudu in Craiova. Namely, the cloud point for the 3D model of the external and internal general church has been used with a width of approximately 10 cm, while steps of 5 cm and 1 cm were used for details of the geometric figures and other aspects which were more difficult to determine, the imposed resolution being that find to achieve the desired and proposed objective [1-3].

2. Material and method

2.1. The church Madona Dudu, Craiova, Romania

The first documentary attestation of the cathedral appears in the year 1758, when on the place of the old wooden church dated 1700, was built a bigger one on stone (between the years 1750-1756), by the great clucer Constantin Fotescu and by the tanner Ion Gheorghe Hagi.

It was built in the brancovenean style (the predominant style of that period) and was provided with apses for the side, having three spiers: one above the nave and two above the narthex. In the years 1800-1801, the entire Craiova was burned by Turks, including the church Madona Dudu; but it was rebuilt in 1842. 1841 is the year when Iordache Oteteleşanu entrusted Constantin Lecca the execution of the painting of the Church Madona Dudu. The painting of the church, which has been completed in 1844, has been carried out in oil in the Western style and has been well received by the people of that time.

Constantin Lecca was the first Romanian painter who carried out the Western church painting style, but according to other sources, the painting of the church would have been worked by Gheorghe Tattarescu, this one being demolished in 1913. The actual construction of the church was carried out according to architects Ion Trajanescu and Sterie Becu plans, being raised between 1929 and 1942 (Figure 1).

2.2. Laser Scanner terrestrial Riegl-390i

This scanner is based on the principle of time-of-flight (TOF) and has a laser source that emits pulses with a wave length of 1500 Nm. This device measures the distances in the range from 1.5 to 400 m with an accuracy of 6 mm at a distance of 50 m in normal lighting conditions and reflectivity. Riegl-390i is a hybrid laser: this means that the scanning is unrestricted in horizontal movement with a field of view of 360 degrees (HFOV) and has a limited field of vision

vertically (VFOV) 80deg (Figure 2). A few technical data of the Riegl specifications are shown in Table 1.

Figure 1. Madona Dudu, Craiova.

Figure 2. Riegl LMS-390i.

The minimum and maximum angular resolution is 0.2° and 0.002°, respectively. The maximum point of measurement is 11,000 points per second. The difference is 0.3 mrad, the equivalent of 30 mm for each period of 100 m. The intensity of the signal received by the sensor system is written in 8 bit [0 255].

Table 1. Some of the technical specifications of the Riegl LMS-390i.

Metrological method	Flight time
Maximum angular resolution	0.002 degrees
Measurement range	1.5 m – 400 m
Accuracy	6 mm (one sigma at 50 m)
Repeatability	4 mm (one sigma at 50m)
Differentiating the laser beam (whole angle, value)	typ. 0.3 mrad
Precision tilt sensors	0.05 degrees

2.3. The method of terrestrial laser scanning

Technology used to scan is 3D terrestrial laser, a new technology, through which the geometry of an object or an area can be measured automatically, without using a reflector, with a speed and accuracy better than those of conventional solutions, which uses technology, or the total station technology or GNSS technology.

Terrestrial laser scanner 3D points was recorded by measuring the vertical and horizontal angles, as well as the distance at every point measured [1; 4; 5; Z. Kang and S.B. Gorte Zlatanova, *Automatic Registration of Terrestrial Scanning Time Based on Registered Imagery (1317)*, FIG working week, Hong Kong]. Even if there are technologies different to a large extent, field use of the scanner 3D adopts elements of the methodology for the total work station, and in order to frame the measurements in the desired projection system, the most useful and quick one is represented by the GNSS technology [4-6] .

In the event that the geometry of the object being scanned is complex (as in the case of front), will be used several points of station in such a way that all surfaces will be scanned and resolution to be as close as possible to reality. In the case in which the shaded areas are not touched by the laser beam, the software automatically captures these areas, then integrates them into the subject scanned [2, 3, 6]. The process is based on the registration of the distances and angles, and the thus obtained data are used to calculate the coordinates of the points for the use of a simple formulae but concrete in the field of the Topography and Geodesy.

Land laser scanning on one hand and total station technology with the GNSS technology on the other hand, resolve any problem. The first one that uses a huge number of points, generically called ‘cloud of points’, the other offering the base used for framing in a coordinate system, in Romania’s case, the stereographic projection system 1970 [1, 4, 5, 6].

Terrestrial laser scanning (TLS) produces clouds of points, with the local coordinate system and additional information (light intensity reflected in the wiring and RGB values obtained from a camera external or internal). The cloud of points, after they have been recorded in different positions, must be brought in line to obtain a complete model of the scanned area using the terrestrial laser. This procedure is called ‘Register’ and involves clouds combining by using the

reflective points connection, specifically designed and delivered by the manufacturer, which is automatically recognized by the scanner [1, 2, 5].

For the case study, in all 6 scanning sessions, we used a Riegl LMS-390i scanner. Medium resolution for all scans was approximately 3.7 mm, and the recorded points have been of millions. Despite the fact that most of the positions were stacked they had a very good performance in giving as faithful as possible the topography of the construction [1, 2].

The processing of raw data was carried out by filtering data using the dedicated Riscan Pro software, and also the recording of data, the reduction in the cloud of points, the creation of a triangulation network and texting the model. The final results of the analysis were produced by the exporting sections, longitudinal and transverse, of the six 3D models independently produced in each session, but which were in conjunction and final model of the church was been obtained.

3. Results

Both inner and outer surface of the church Madona Dudu have been scanned from different points of view and laser scanning stations. All measurements have been suitable in the Riscan Pro software. Figure 3 shows the different positions of the scan stations.

Figure 3. Madona Dudu, Craiova (Source Google Maps).

Crossing points (targets) tie objects defined by the user and polydata objects. These objects polidate represents the reduced (processed) version in the clouds original points. ICP algorithm could be very slowly when using a cloud of dense points. To accelerate the process, the number of points is reduced by their representation with specific items and preferences. Once the registration is

performed, recording the various scanning positions are obtained with a standard deviation of 3.7 mm.

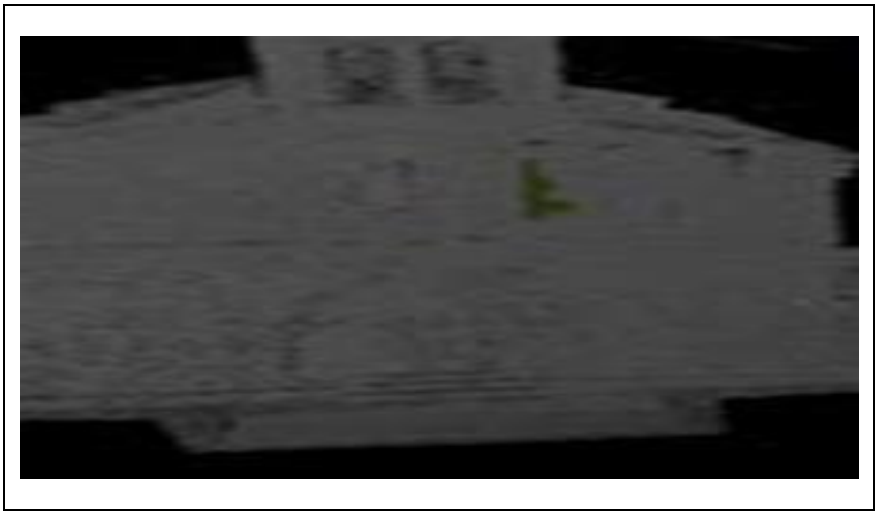

Figure 4. 3D model produced with external scan (a cloud of points).

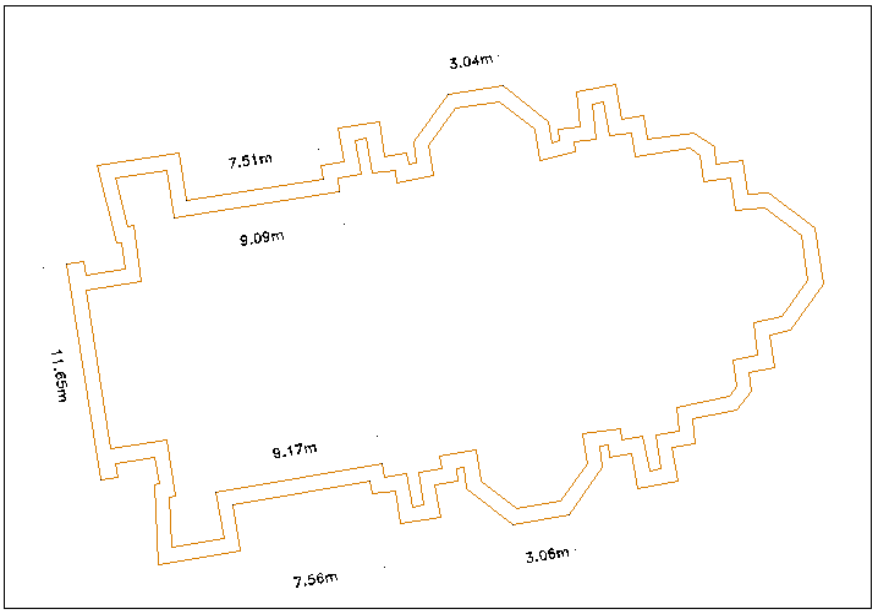

Figure 5. Section report building in a CAD system.

A number of cross-sections have been carried out in the three dimensional model and exported in dxf format (Drawing Exchange Format) to be used in a CAD system. Figure 4 shows the results of the cross sections made on the 3D model produced with external scan (a cloud of points).

Figure 5 presents the concerned report buildings (church Madona Dudu) according to the methodologies in force and as a result of the latent and constrained laser scanning and forced on the cadastral measurements, which have been made and are recorded at the Office for Cadaster and Land Registration in Dolj County.

4. Conclusions

Cultural heritage can be affected by external and internal many factors or by the passage of time the value of historical heritage conservation may affected. Therefore, the inventory and documentation has become essential for the health information and heritage protection available to a country and in particular in the field of religious monuments, which is highly appreciated in Romania. The restoration in the event of damage (earthquakes, flood, fire or other) can be improved by documentation that can be stored in the information systems and software. This study shows that the scanning with laser techniques, can be applied in order to obtain a three-dimensional model (3D) and to extract the cross or longitudinal section of the respective cultural heritage (in our case of the church).

Laser scanning techniques have changed the paradigm of measurements, and they lead to a complete and accurate geometry of models, which are obtained with less effort in a shorter time than the measuring technique based on classical methods. As a result of this work, using the new measuring technique, i.e., the terrestrial laser scanning technique, the Church Madona Dudu in Craiova has been modelled and digitally archived.

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