TLS AND DIGITAL PHOTOGRAMMETRY STUDIES IN CULTURAL HERITAGE DOMAIN

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Summary: *The documentation of cultural heritage through the acquisition of digital data and the realization of 3D models currently can count on many procedures and survey instruments which have been developed in the last decades and still more specialized for the acquisition of metrical information with high resolution levels, reliability and precision. The paper proves its applicability as photogrammetric technologies are nowadays used at a large scale for obtaining the 3D model of cultural heritage objects, efficacious in their assessment and monitoring, thus contributing to historic conservation. Its importance also lies in highlighting the advantages and disadvantages of each method used – very important issue for both the industrial and scientific segment when facing decisions such as in which technology to invest more research and funds. For cultural heritage purposes, the 3D models of the Martyr's cross monument realized in this comparative study meet the accuracy criteria and sustain the idea that not in every modeling process there is much need of using highly technical or expensive technology as a realistic and feasible methodology for documenting cultural heritage objects with the aid of GIS.*

Keywords: *Cultural Heritage objects,3D Models, Terrestrial Laser Scanner, Digital Photogrammetry, Image Processing*

1. INTRODUCTION

Cultural heritage documentation includes an interdisciplinary approach having as purpose an overall understanding of the object itself and an integration of the information which characterize it. This integration is nowadays realized in GIS mediums which are suitable for handling vast amount of geospatial data and offering detailed investigations on the object of interest. Because a cultural heritage documentation involves diverse areas of specialists and also huge data, besides the spatial information itself, the most suitable manner of managing all this various data, starting with collecting, interpreting and sharing it and the results of its interpretations, is on GIS

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platforms (preferably web-GIS and Open Source platforms) [1]. Also, a special attention should be paid to ensuring both standardization and interoperability of the data.
On the other hand, the term GIS is characteristic to land management applications; the term "geographic" traditionally being connected to an international cartographic reference system. Considering the geometric deformation of the geographic reference systems, the term "geographic" can be misinterpreted, therefore an idea is to use the generic term Spatial Information Systems (SIS) for Cultural Heritage applications of GIS technology according to Rinaudo et. Al [2]. This assumption means that usually local reference systems (both continuous and discrete ones) are used to locate the acquired data; geographic coordinates (or global reference systems) can be used as ancillary information in order to locate the objects in a more general context.
A particularity of the SIS, which confirms its suitability for cultural heritage documentation, is that it integrates data collected with all the technologies specific to geomatics's domain: total stations, GPS, terrestrial laser scanners, LiDAR, InSAR, UAV, digital photogrammetry, remote sensing. A much greater amount of information is obtained using the 3D model than 2D drawings [3]. Once completed the 3D model, we can generate any orthogonal projection or centred on the object.
The main advantage of photogrammetric modeling is the cost of the procedure. Field work is considerably reduced compared to classic surveying method which imply measuring all dimensions on the field.

2. DATA SURCES / DATA AQUISITION

Martyr's cross monument is located in Mihai Eminescu Park in Arad, Romania, a crowded and important place just behind the City Hall and in close proximity to the Palace of Culture. The monument was built in 1936 following the sketches of the city's Chief Architect, Sylvester Rafiroiu, in memory of Romanian Orthodox priests martyrs from 1918-1919. Originally the cross was placed in the Vineyard square, being removed by the Communist authorities in the 1960s, for 30 years has been preserved in the monastery of Gai. It was restored on its site in the 1990s.

Trimble laser scanner characteristics

For retrieving data through 3D laser scanning technology, issue debated by authors in the specialty literature [4], [5], we used Trimble TX5 laser scanner. It features a quick-acting laser, capable of measuring up to 976.000 points in one second, up to a distance of 120 metres and an integrated camera, able to make panoramic photos up to 70 megapixels. Adding these pictures over the point cloud resulted from the scanning process, photorealistic 3D images will obtained. The scanner has a two-axis compensator, an electronic compass and an altimeter, these enabling the registration (linking station) of the scans. The control software is very easy to use, being created in a logical and intuitive manner. Surveyed data is stored on a SD memory card, which can be later transferred to a computer easily. After downloading, data may be processed in Trimble RealWorks software, which provides various commands for advanced 3D modeling and processing of the point clouds.

B. TLS 3D modeling of the Martyr's cross monument

Similar to any traditional topographic word, the 3D scanning process starts with the study of the terrain and of the object to be measured. To have an operative and accurate campaign of measurements, we came to the conclusion that 3 stations in which the scanner to be set would be enough. After determining the approximate location of the stations, the spherical targets were placed in order to facilitate the registration process. The scanning session lasted 40 minutes and the processing of the data was realized using Trimble RealWorks software.

Once the scanned data is imported, the point cloud is created and the operator has the possibility of customizing it by choosing the number of points, their density etc. In this phase, the scans are not connected, so by using the panoramic photos realized during the scanning process, the targets will be selected in order to register the scanning. The software offers has 2 options: either it selects automatically the circular targets from a user defined area or the operator manually (Fig. 1) chooses the targets.

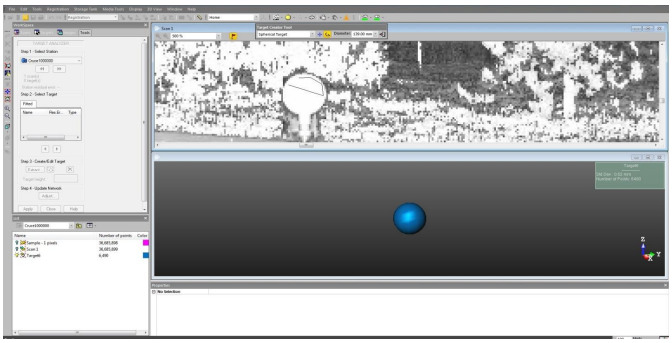

Figure 1 Manually inserting the targets

Once the selection of the circular targets is finished, by using the "Adjust" command, the link between the scanning stations (Fig. 2) is created and the registration details are transmitted: the residual error for each station and target.

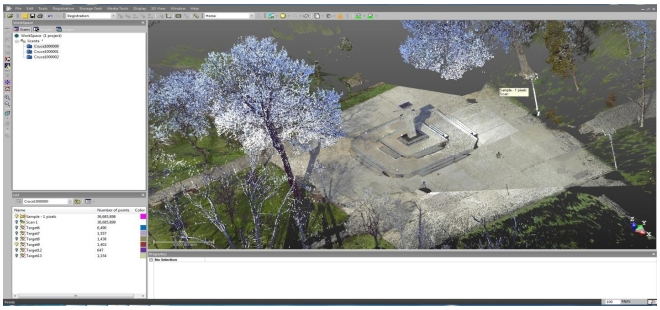

Figure 2 The point cloud after registration

For better visualization purposes of certain details of the point cloud and to reduce the noise, different tools for the selection of certain portions of the point cloud are available, also called areas of interest. Because in this case we are interested only in the Cross of

the Martyrs, we remove all the other points that are surplus. The command which enables this procedure is "Segmentation Tool". Once selected the area of interest, we can move on to the actual modeling of the point cloud. The cloud will be modeled with mesh surfaces. This command can be selected from the "OfficeSurvey" module and then "Mesh Creation" command. We create the mesh for the socle and the cross (Fig. 3).

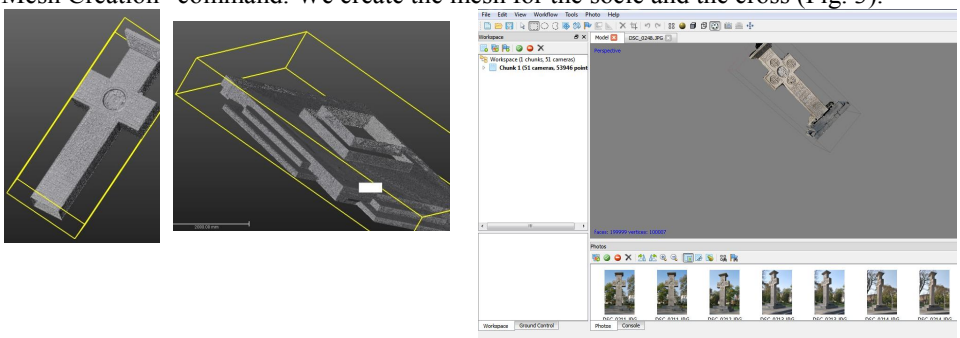

Figure 3 The meshes for the cross and its socle and with texture on it

C. ***Digital photogrammetry 3D modeling of the Martyr's cross monument***

The shooting session of the Martyr's cross was achieved using a compact (DSLR) Nikon D60 camera. About 50 pictures of the monument were taken, but, for the creation of this model only 17 images have been used. The photos were taken from about 10 metres from the monument, at a distance of approximately 2 meters between each position of the observer (operator).

An advantage is represented by the fact that preparing for a digital photogrammetric application such as the one described above does not require previous training, involving for the field work, only the use of a digital camera, a total station or a measuring tape.

As regards the specialized software, it is fully automated to create the point cloud, build the geometry and the texture of the object. User only cuts out the unnecessary points, which are not important for the modeling around the object. It is recommended to use PhotoScan for the objects with complicated geometry. The speed of the calculation depends on hardware capabilities of the computer [6].

3D modeling technique based on images demonstrates the useful character of digital photogrammetry for accurate 3D modeling and visualization of the actual objects which respect regular geometric shapes (monuments, buildings etc.). The accuracy with which the 3D models are obtained (less than one pixel) corresponds to applications in the field of assessment and conserving cultural heritage, thus photogrammetry can become the best alternative to traditional measuring techniques.

Analysis of the 3D models obtained and proposing a general workflow

The importance of the comparative study is reflected by the practical usefulness of the specialized software, through which 2D and 3D models can be realized, using relatively easy to use equipment. Furthermore, a comparison between different techniques and technologies always brings value from the economic point of view.

The models recorded with the above-mentioned technologies were ready for 3D visualization a few hours after data capture [7]. Some advantages and disadvantages of

3D modeling using the terrestrial laser scanning and digital photogrammetry are highlighted in the following figure (Fig. 4).

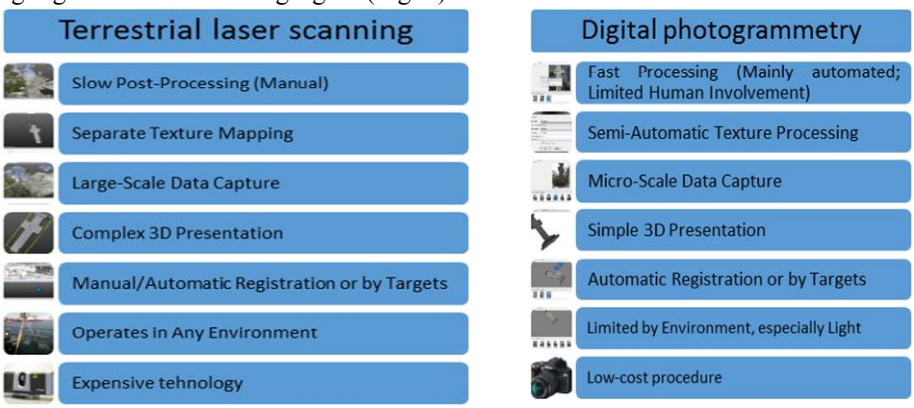

Figure 4 Advantages and disadvantages of the methods used for 3D modeling

The GIS solution is usually understood as a desktop solution. Many books and manuals on GIS technology talk about a GIS application and its subsequent publication on Internet [8]. Nowadays, it is possible to conceive a new type of GIS project based on a client-server approach using a relational spatial database where all data (e.g. geometric, alpha-numerical) can be collected together and directly managed by the client application on the WEB.

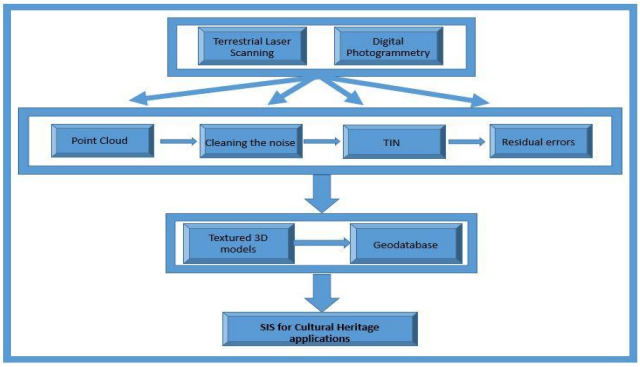

Fig. 5 Workflow from laser scanning and digital photogrammetry to 3D modelling and visualization to WebSIS

Thus, the authors propose a general workflow (Fig. 5) for documenting cultural heritage applications aiming to later create a Spatial Information System published on the WEB.

3. CONCLUSIONS

By the comparative study of the two methods used for creating a 3D model, we can conclude that there are both resemblances as well as differences between the two technologies presented. Depending on the complexity of the work, the need for accuracy and the necessary funds allotted, one can choose the most suitable method which meets the criteria mentioned above. By comparing the time needed to realize the 3D model, laser scanning is relatively time-consuming compared to the digital photogrammetric method which, instead allows for immediate results. As regards the accuracy, the scanning is once again more accurate, by creating a 3D model very close to reality; instead, regardless of software and photos taken, by photogrammetric methods, the model is close to reality, but not very accurate. Laser scanning requires longer post-processing, but produces higher quality data. From the financial point of view, incontestably the photogrammetric methods are much cheaper than 3D laser scanning, even though the present work has been carried out using one of the cheapest scanners on the market. Nevertheless, laser scanning campaign's cost, along with software for data processing, is somewhere around the amount of 50.000 euros. Instead, the photos can be taken with any digital camera, 3 megapixels, including with the camera of your phone. The cost of this method is substantially lower. Regarding the workflow proposed for 3D modelling and visualization to WebSIS, the conclusion is that the future brings changings in terms of replacing desktop solutions by WEB solutions in order to allow the dissemination of the results and to increase the possibility of international collaboration between specialists.

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ТЛС И ДИГИТАЛНЕ ФОТОГРАМЕТРИЈСКЕ СТУДИЈЕ У ДОМЕНУ КУЛТУРНОГ НАСЛЕЂА

Резиме: *Документовање културне баштине кроз набавку дигиталних података и реализацију 3Д модела тренутно може да рачуна на многим процедурама и инструмената истраживања који су развијени у последњим деценијима и још специјализованих за прикушљање метричких информација високе резолуције, поузданости и прецизности. У раду је приказана примену фотограметријске технологије која се данас користи у великом обиму за добијање 3Д модела објеката културне баштине, ефикасних у њиховој процени и праћењу, доприносећи тако историјском очувању. Његов значај је и у истицању предности и мане сваке коришћене методе - веома важно питање и са индустријског и научног аспекта када се доноде одлуке у коју технологију инвестирати више истраживања и средстава. За потребе културног наслеђа, израђен је 3Д модели а унакрсног споменик испуњавајући критеријуме тачности и одржавајући идеју да није потребно у сваком процесу моделирања користити високо техничке или скупе технологије као реалну и изводљиву методологију за документовање културног наслеђа објеката уз помоћ ГИС-а.*

Кључне речи*: објекти културне баштине, 3Д модели, земаљски ласерски скенер, дигитални фотограметрија, обрада слике*