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"MULTIDISCIPLINARY APPROACH TO CONTEMPORARY RESEARCH"

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CONTENTS

THE VISUALIZATION OF THE MEDIEVAL SITE OF THE SAVINAC MONASTERY

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Abstract: *Contemporary visualization techniques rely on new technological achievements which offer information data collection in the form of a three-dimensional model. Such 3D model is significant in the area of cultural heritage protection and specifically in the restoration processes of ruined monuments. The results of applications of both methods, terrestrial laser scanning (TLS) and photogrammetry, is 3D data in the form of point cloud, which is a base for 3D modelling process in adequate software, and accordingly, a creation of an objects' 3D shape. In this paper, the results of data collecting at the medieval site of the Savinac monastery (twelfth century), performed in 2018, by using both contemporary methods, is presented. The visualization of this particular site is of the major importance for cultural heritge of Serbia.*
Key-words: *Visualization, Serbian medieval monastery, terrestrial laser scanning, photogrammetry, 3D modelling, point cloud.*

1. INTRODUCTION

The visualization process of a monument assumes graphic representation of data in order to obtain visual communication/information with any consumer. The advances of a visual communication against verbal comunication, or a data obtained from the tables, are strong and obvious in terms of a better understanding of graphic representations. Besides, the visualization of existing monuments, by using 3D models, opens a range of further processing possibilities and data application, such as following ones:

- Creation of a digital base for technical, historical (chronology of construction process) and other data on an object (a state of a structure, humidity, etc.);
- Reconstruction and renuwal of a monument;
- Creation of 3D prototypes, along with virtual tours (animations);
- Geometric and other analysis;
- Continuous survay of a monument througout the time continuum.

Contemporary reconstructions of historical monuments that use *Historical Building Information Modelling* (HBIM) platform rely on data obtained by terrestrial laser scanning (TLS) and photogrammetry. These data, i.e. point clouds are the base for the creation of solid

models of monuments [1]. Once obtained semantic information has its purpose in creation and screening of geometricaly defined models, and additionally, in later survay of the life cycle of a monument [2]. In the cases of object's reconstruction [3,4], 3D point cloud could be used for an adjustment of designed parts of a monument to its' existing parts (remains of the walls or other structural parts of the monument).

This paper presents the case study of the visualization of the medieval site - the Savinac monastery in Serbia, which is currently in the initial phase of the monuments' reconstruction. The results of this paper will be used in the further process of creation of the technical documentation on the monastery church, as well as for accuracy checking of the reconstruction proposal. As the 3D digital record, these point cloud data are of great significance, in overall historical context of the Savina monastery life cycle, and particularly for the time segment before the reconstruction phase.

2. THE LOCATION OF THE SAVINAC MONASTERY

The remains of medieval site Savinac are on the slopes of Fruška gora mountain in the village Klisa (**Fig. 1**). There are no certain information about the time of construction of the church known as St. George's church. Some indications point to the twelfth century and the Nemanjić dynasty patrons.

Figure 1: Location of the Savinac monastery

Some rare records from the books being preserved in the Fruška gora monasteries testify of the existance of the Savinac monastery (named after St. Sava), to whome all the written historical traces dissapeared after the Turkish conquest of the Serbian territory. Was the church of St. George, the one we know now as the church of the Savinac monastery, or it was the church of St. Prokopius (also mentioned in some historical sources), it is not possible to claim true, based on the preserved historical records. What is known for sure is that the church belonged to the Orthodox tradition, because it is oriented in east-west direction, so that the altar is on the east side. On the west side of the regular rectangular nave the bell-tower appears of which only the outer walls have being preserved. The remains of the side walls of the church are approximately three meters tall, while the semicircular wall of the apse is barely a few centimeters above the

ground. A shallow semicircular arch made of stone appears at the juncture of the apse and the nave. The current appearance of the church is shown in **Figure 2.**

Figure 2: Savinac monastery site

2. DATA COLLECTING METHODS

In this scientific work the two methods are used for the data collection at the medieval site of the Savinac monastery in Stari Ledinci. These methods are terrestrial laser scanning and photogrammetry. Both methods are equally present in the contemporary data collecting streamline regarding cultural heritage monuments, and especially the ones which rely on HBIM platform [1,2].

2.1 Terrestrial laser scanning method

Terrestrial laser scanning is an efficient and fast method for collecting of large amount of data. For the scanning procedure terrestrial laser scanner is required. Scanning procedure has to be performed from a certain number of stations around the object, in order to merge multiple scans into unique 3D point cloud during registration process [5] (**Fig. 3**)

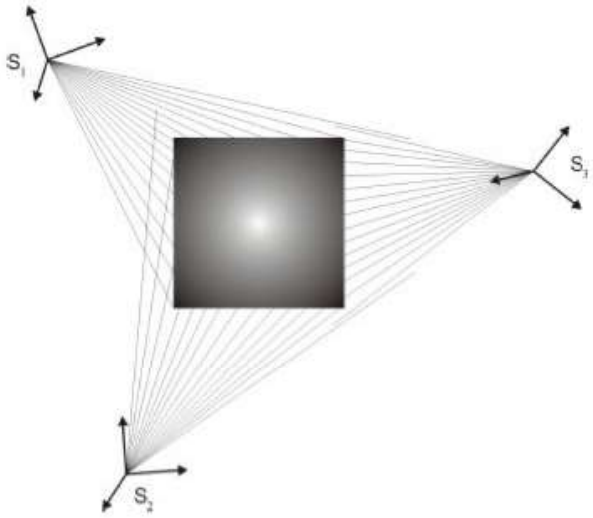

Figure 3: Point cloud registration [5]

Collected data appears in the form of point cloud, with four-dimensional information about each point:

- Three dimensional coordinates (X, Y, Z);
- Intensity of backward radiation.

Scanned object is discretized with large amounts of points, so it is possible to obtain real 3D model of a limited usage. A modelling procedure of a point cloud which has to be performed in adequate software for modelling provides CAD compatibility form of a building, which can be later used for various purposes.

2.2 Photogrammetric method

Photogrammetric method of data collecting implies "image based modeling", i.e. it is based on image processing in adequate software. The procedure of photo shooting for an object/building has to be performed from a certain number of sites around the object/building, due to its' complexity. The overlap image rule [6] has to be satisfied as well. In order to create 3D object from the series of photographs, GPS camera location is required for each shooting position. The simplest and the most effective approach implies the use of a camera with integrated GPS. The result of data processing, obtained in specific software, is a 3D structural model of an object/building, in the form of a photorealistic point cloud. The final modelling result is a 3D surface model.

3. VISUALISATION OF POINT CLOUD DATA

Visualisation of the monastery church, for the purposes of this project, was executed with data collected by the two previously presented methods.The results of a usage of these methods are point clouds, which are the basis for creating of 2D deliverables and 3D mesh models.

3.1. Terrestrial laser scanning procedure

As already stated, the scanning procedure at the site is performed by a high accuracy laser scanner - FARO Focus 3D (**Fig. 4**) with characteristics presented in the **Table 1**.

Table 1: The characteristics of FARO Focus 3D

Characteristics	Values
Wavelenght	905nm
Laser power	20mW
Scanning speed	976000 points/s
Maximum range	120m
Working temprerature	+5°C do +40°C
Field of vision	360°/305°
Measurements accuracy of distances	2mm/25m

Figure 4: FARO Focus 3D

Scanning procedure has been performed at the total number of 13 stations around and inside the church (**Fig.5**). Individual scans are registered (joined) into a single - global point cloud, which served for the further modelling. Registration of scans was performed in Autodesk's

software ReCap. The appearance of a global - registered point cloud of the church remains is presented in **Fig. 6**.

This unique point cloud represents a rich information system of the object, i.e. rich source of data, which is a solid base for the further analysis such as dimensioning necessary for reconstruction design of the church.

Figure 5: Plan view - the scanner positions

Figure 6: View of a global point cloud

3.2. Photogrammetric data collecting procedure

Photogrammetric survey was performed by Nikon D5200 24.1 MP CMOS Digital SLR Camera (**Fig.** 7). Total number of photographs is 209, with following settings: exposure time 1/80; aperture f/3,5; film sensitivity ISO 250. Based on the focal length of camera, GPS location and lens parameters (*Altura Photo 8mm* f/3.0 Aspherical Fisheye Lens) the processing of the images was performed. In Agisoft photoscan software 202 photographs were successfully used for creation of the point cloud with total of 21 033 257 points (**Fig 8**). Final 3D model of the church is created by using the triangulation method of a point cloud (1 394 282 triangular areas). Then, the model was imported into Blender software for its scaling and production of different views (orthogonal and perspective) as well as cross-sections. (**Figs. 9-11**). The animation of the 3D model is created in the same software environment.

Figure 7: Camera [8]

Figure 8: Point cloud obtained by photogrammetric method

Figure 9: Model of the monument: – layout (top view)

Figure 10: Model of the monument: perspective view from the east side

Figure 11: Model of the monument: perspective view of the entrance with the bell-tower

The model of the church based on photo images has more photorealistic appearance, than the one obtained by scanning data, while its accuracy is lower, considering perspective deformations of photo images (this is characteristical for the images of the higher parts of the church).

4. CONCLUSION

The result of this case study are 3D poit clouds and 3D mesh model of the medieval church of the Savinac monastery alog with their deliverables - characteristic views, sections and animation of the model. This material has a potential as a valuable source for the further reconstruction process of the currently ruined church, both in terms of creation of precise technical documentation and design (reconstruction) of the missing church structure. These accurate data, seen in a wider context represent the unique historical record in the overall digital repository of Serbian medieval cultural heritage, which could be of use for the prediction of a further life-cycle and maintenance of the particular monument.
In general, permanent technlogical advances in data collection techniques and software solutions offer wide range of possibilities in the context of visualisation of cultural heritage monuments. Visual representations that are based on relatively new technologies (TLS and photogrammetry) and aided by adequate software solutions enable a creation of very realistic 3D models of monuments. They could be potentially used for various purposes such as:

- the creation of technical documentation;
- digital data repository of a monument;
- the further design-reconstruction process, maintenance and prediction of a life-cycle;
- geometric or other analyses;
- the creation of a 3D prototype;
- various 3D animations etc.

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