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3D SCANNING AT VINČA – A SOLUTION FOR CONSERVATION AND STUDY OF CULTURAL HERITAGE

Abstract. We concentrate on the problems of conservation and presentation of the vertical section of the site of Vinca near Belgrade. This important archaeological site is endangered by numerous threats. The nature of this object, almost 300 meters long and more than 9 meters high, composed mainly of eolian sediments and deposits of human activities, makes it unstable and succeptable to deterioration, which prompts for immediate action. The first stage has been recording of the present state of the object. A 3D scanning of the section has been performed on a larger part of this section. This enables present-day and future researchers not only to observe the vertical section of the site, but also to make measurements and perform virtual research at the part of the site which will be conserved with a massive land ramp.

Vinča is one of the few places in the World that has witnessed more than 7500 years of continuous history. Vinča was first inhabited around 5600 BCE, when Starčevo people of the Early Neolithic, a population that occupied this region in centuries before the appearance of the Vinča culture, established a small settlement on the right bank of the Danube. The reason for such longevity can be found in an excellent geographical position of the site. It has an outstanding visual range of the river, which is a vital advantage to its inhabitants.

Furthermore, Vinča – Belo Brdo has a central position in the Balkan Peninsula, which makes it a focal point for trade and communication. Its hinterland is rich in wood, mineral ores and wild game, as well as fertile soil in the valley of the Bolečica River, which empties into the Danube nearby.

The archaeological research at the site of Belo Brdo in Vinča has lasted throughout the better part of the 20th century. As we have mentioned before the first person to start the excavations here was Miloje M. Vasić – often called "the father of Serbian archaeology". Thanks to this man and to the unsurpassed beauty of its figural plastics, Vinča has become one of the greatest cultural phenomena of European prehistory, to the degree that the entre Late Neolithic of Southeast Europe can be characterized by the Vinča culture.

The new campaigns, which commenced in 1998, have been marked by innovations in archaeological methodology and the introduction of new technologies that aim to preserve the archaeological context and its context thoroughly. The key words for this research are inter-disciplinary approach, protection and presentation, as it is most appropriate to this cornerstone of world archaeology.

The Belo Brdo site in Vinča is situated on a *Panonnian ridge*, a steep geological formation, extending from Belgrade to the city of Smederevo, along the right bank of the Danube. Its main morphological characteristic is a steep angle of descent towards the Danube (at

certain places angles of descent exceed 60°), occasionally softened by landslides and other geodynamical processes to average 20°. The complex and heterogeneous Tertiar lithic composition of the soil is the main cause for its geological instability, which often leads to the mechanical processes such as landslides and water induced erosion. Alongside these geological conditions, the archaeological site of Belo Brdo is endangered by intensive human activity on and in the immediate vicinity of the site.

The key feature of the site is its vertical section (profile) on which all the layers and horizons of entire life span of the site are recorded (Fig. 1). Due to the fact that a large part of the site has already been lost as a result of erosive forces of the river Danube in the past, and also to the fact that only a smaller size of the site has been excavated so far, the vertical section of the site is of utmost importance. Since the site itself and its vertical section have such an importance for Serbian and European prehistoric archaeology, the concentrated efforts are due to be undertaken on preserving it as promptly as possible (Fig. 2). After a thorough consideration of the methods of preservation of the vertical section of the site of Vinča, the expert team has reached a conclusion that the most effective means for achieving this goal would be the construction of protective ramp which would prevent its pieces from falling off (Fig. 3). In order to preserve the exact position and information preserved in the vertical section of the site prior to its conservation, 3D scanning of the profile has been performed. This method is ideal for recording the exact shape, color and measurements of the profile. In this way it would be possible for the researchers to study this part of the site even after the protective ramp is erected.

3D laser scanning is a technology of acquiring tridimensional data which enables fast, accurate and detailed "digitalization of real world objects" i.e. acquiring digital data on the object scanned. The result of scanning is extremely rich cloud of points in the computer which represents very realistically the object (Fig. 5). The millimeter accuracy of this system and precise 3D coordinates guarantee the quality of the scanning process.

Scanning of the archaeological site in Vinča was performed in April 2008 as a result of a cooperation between private company Vekom and the Department of Archaeology of the University in Belgrade. It has been performed with 3D laser scanner Leica ScanStation2, which is a product of Leica Geosystems from Switzerland (Fig. 4). ScanStation2 is one of the top models of this company and represents the best solution for this sort of application. The basic technical characteristics of ScanStation2 are listed in the following table:

Accuracy of single measurement	
Position (3D)	6mm
Distance	4mm
Angle (horizontal/vertical)	60 μrad
Modeled surface precision**/noise	2 mm, one sigma
Range	300 m @ 90%; 134 m @ 18% albedo
Spot size	From 0 - 50m:4mm (FWHH - based)
Maximum sample density <1 mm1	
Field-of-view (per scan)	
Horizontal	360°
Vertical	270°
Target acquisition***	2 mm std. deviation
Dual-axis compensator	Resolution 1", dynamic range +/- 5'
Digital camera	integrated 1MPixel Full 360° x 270° dome: 111 images, approx. 64 megapixels, automatically spatially rectified

The scanner is controlled via notebook computer linked with the scanner over a TCP/IP Ethernet link. Leica Cyclone software is a program used to acquire and manipulate the data acquired during the scanning process. This program represents a complete solution for manipulating cloud of points. Another possibility is Leica CloudWox, which is a plug-in for Cad software (AutoCad, Microstation), which also supports work with cloud of points.

Scanning of the vertical section in Vinča was accomplished in one day. Due to the dimensions and the shape of the profile scanning was done from 4 positions (Fig. 6). These had been chosen as to encompass the entire section of the site. The points were scanned in 1cm@30m precision. Before the scanning, integrated camera had made photos of the section. Based on the panoramic photograph obtained in a step before, selection of the surface to be scanned was undertaken. Scanning of each position lasted between 20 and 25 minutes, depending on the size of surface selected. After scanning had been finished, precise positioning of markers, installed on and in the vicinity of the vertical section of the site, was performed. These data are to be used for stitching of scanned clouds of points into a single cloud of points and its georeferencing, which has been done using Leica TCR307.

After the data acquisition the processing of the data were done in the office using Leica Cyclone software. The steps are the following:

- Registration of cloud of points: stitching of individual clouds of points into a single one and its georeferencing, using gathered local coordinates;
- „Cleaning“ of the model: erasing unnecessary points outside the model (surrounding objects, vegetation, passers-by);
- further detailed post processing;

Further post processing depends on the nature of the end product needed. In this case it was possible to do the following:

- Direct measuring and drawing: in the cloud of points it is possible to perform direct measurements of individual points or to create 2D and 3D drawings;
- Visualization: “coloring” of the cloud of points into realistic colors collected from the photograph (either from the scanner or from another camera). In that way the cloud of points can be used for effect 3D presentation of the Vinča profile (Fig 7);
- Modeling: creation of 3D model on the surface of the profile and use it not only for visualizing purposes but also for other calculations. It is also possible to print it on different 3D printers and obtain physical model of the site;
- Publishing over the internet: the model is ideal for publishing on the web. Using Leica TrueView software (freeware) it is possible to allow online users to make use of the result of the 3D scanning of the site of Vinča. This software enables 3D representing of the site, 3D navigation, direct measurements on the model, marking of different points of interest and attributing text and hyperlink labels to them (Fig. 8) ;
- Animation: using Cyclone software one can create attractive animations (3D flight) for multimedia purposes (Fig. 9).

The importance of vertical sections on multilayered archaeological sites has always been recognized among archaeologists. It is particularly the case when the site of Vinča is concerned. Its importance within wider cultural-chronological framework makes this profile irreplaceable. Researchers at every site that belongs to the Late Neolithic period in the entire southeastern Europe make use of Vinča’s vertical section as a yard-stick for relative-chronological positioning of each and every one of them. In this way, by the means of 3D scanning and protecting physically it from the further deterioration and decay we have tried to preserve it for the future.

Illustrations:

Figure 1 – The vertical section of the site of Vinča

Figure 2 – Deterioration of the vertical section

Figure 3 – April 2008, 3D scanning at Vinča

Figure 4 – Leica ScanStation 2

Figure 5 – Cloud of points from the Vinča profile

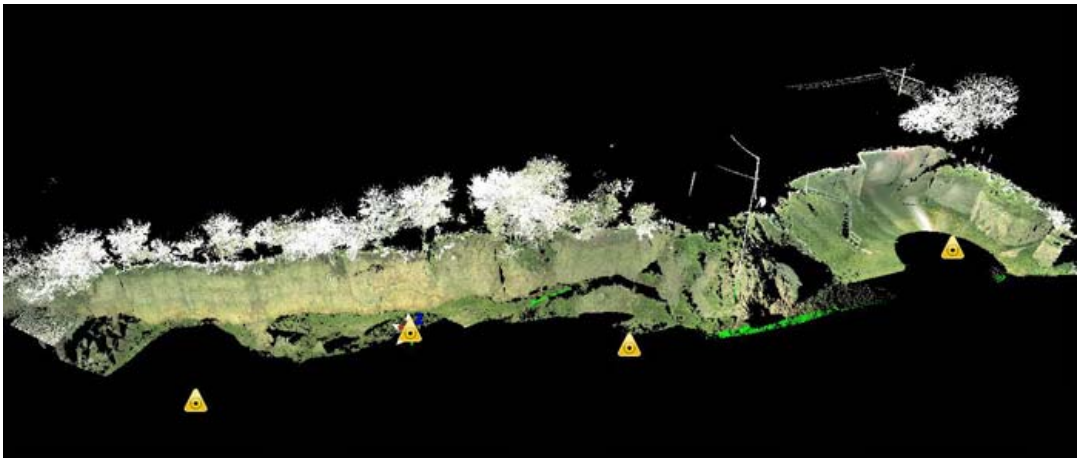

Figure 6 – Positions for individual clouds of points taken during 3D scanning at Vinča

Figure 7 – Colored cloud of points

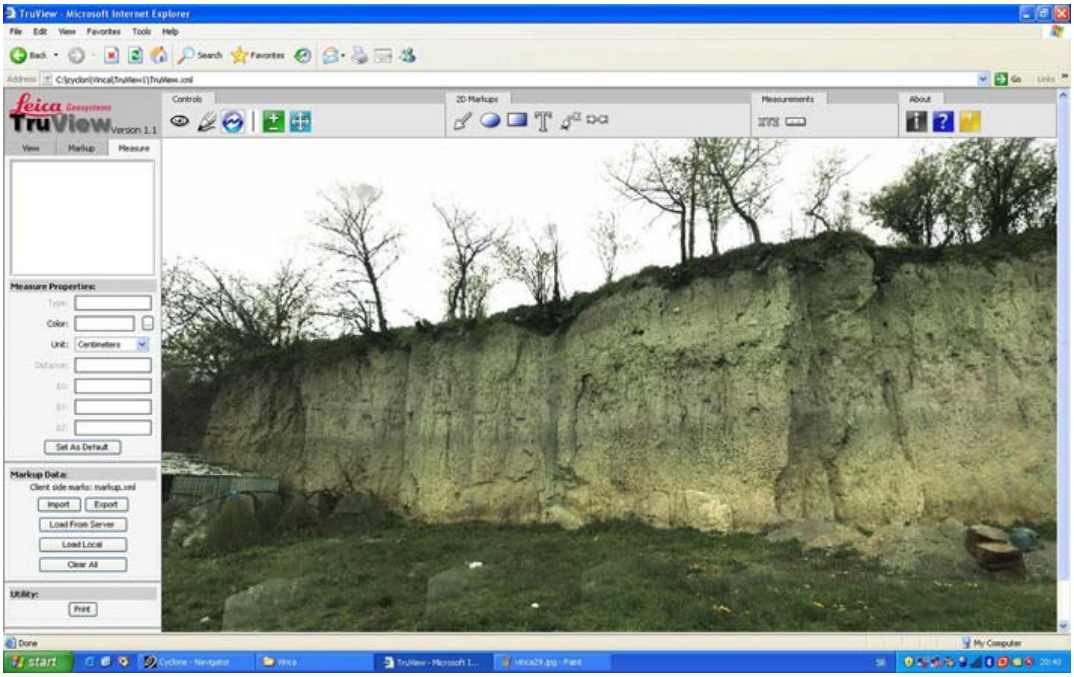

Figure 8 – A screen taken from TrueView software

Figure 9 – A part of the 3D scan of the site of Vinča