

Airborne Laser Scanning Technology in Archeology

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Abstract – The article touches upon the issue of the application of the technology of laser scanning in archaeological research of various monuments of architecture, culture and antiquity. The authors consider the principles of laser scanning, its main types (ground, mobile and air), as well as the global experience of using airborne laser scanning in archeology on the example of individual countries. The research describes the actions to address the problem of introducing this technology into archaeological research taken in relation to the monument of antiquity - Red October settlement near Temriuk, located in the Krasnodar Territory, as well as instruments and software used in this process. According to the results, the authors made the conclusions about the main advantages and disadvantages of laser scanning as a tool for research in archeology. In addition they presented in comparison the alternative methods in the form of the photogrammetric method.

Keywords – *archaeology; airborne laser scanning; archaeological research; airborne laser scanning; drone.*

I. INTRODUCTION

Nowadays laser scanning, due to its speed and high accuracy, serves as one of the most advanced means of obtaining a digital three-dimensional model of surface, representing a cloud of points, which has spatial coordinates and orientation [9]. There are many areas in which this technology is widespread, ranging from construction to the oil and gas industry. Relatively recently, it began to be used in archaeological research [3].

The principle of the action mechanism of laser scanning is to use high-frequency laser radiation for shooting certain objects and to capture reflection from them by a special receiver with parallel fixation of parameters in XYZ surfaces and coordinates by an inertial system which is the addition to a scanner. The high frequency of scanner provides a high density of points forming a cloud, which allows obtaining detailed information about the smallest details and parts of the scanned object [8] during the creation of final three-dimensional model.

There are three main types of laser scanning [4]:

- Ground laser scanning (it is performed with the help of static installation, usually in several stages, with a separate scanning of each surface, which are later combined with the use of software into a single three-dimensional complex);
- Mobile laser scanning (it is performed with the help of vehicle that moves along a predetermined trajectory, with particular attention being paid to the rigidity of the scanning installation, which nevertheless has its own built-in vibration compensators, which eliminates the possible appearance of distortions and inaccuracies);
- Airborne laser scanning (it has the most extensive scanning area and speed, the final product of which are high-quality geometric landscape plans. It provides detailed characteristic features of landscape, vegetation, constructions of buildings and structures, transport infrastructure, etc. There are also technologies which make it possible to classify the cloud of points in an

automated mode with the allocation of certain objects for further manipulation specifically with each of them).

Nowadays the airborne laser scanning is actively applied in archaeological research.

II. METHODS AND MATERIALS

The examples of global experience of the usage of airborne laser scanning in archeology by various organizations are presented in the table 1 [2–4].

As a part of the promotion of a program to solve the problem of archaeological research with the help of airborne laser scanning, the Red October Settlement near Temriuk was scanned. It is located on the eastern outskirts of the of Red October village and consists of two fortified parts and a large suburb with burial grounds with a total area of up to 10 hectares.

In old times, the settlement was surrounded by stone walls with towers and gates, which are now destroyed and covered with sod, and the two fortifications were divided by a deep ditch. Archaeologists date the Settlement in the 5th century BC, suggesting that the population consisted mainly of Greeks and individual representatives of local tribes.

It is necessary to note that before the implementation of the program of scanning the Settlement, the scientific - research group had extensive experience in various landscapes scanning (Fig. 1–2).

Airborne laser scanning of the Red October Settlement was carried out with the use of an airborne laser scanner, which was made by VLS AGM-MS3.100 produced by “AGM Systems”, with the following technical characteristics:

- Spatial accuracy of measurements - 3 cm;

- The density of the point cloud of aerial laser scanning 300 points per 1 square meter

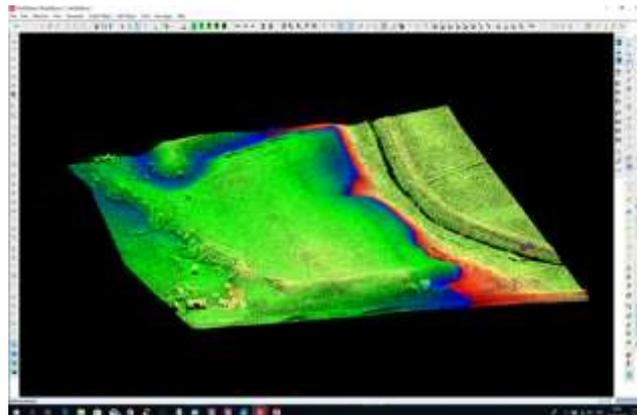


Fig. 1. Scanned territory

DJI Matrice 600 PRO drone was used as an air carrier. During the survey, the flight speed of drone was 5 m / sec; the scanning itself took place at the height of 50 m above the Settlement and took 15 minutes. In the subsequent processing of the scanned point cloud, the advanced software was applied in the form of the following programs:

- Bentley MicroStation;
- TerraSolid TerraScan TerraModeller [10];
- Autodesk Civil 3D.

TABLE I. USE OF AIRBORNE LASER SCANNING IN ARCHAEOLOGICAL RESEARCH

Place	Archeological site	Problem solved by laser during the process of landscape scanning	Result
Asia, the territory of medieval Cambodia	Angkor, the capital of Khmer State with Angkor – Wat Temple	A curtain in the form of a tropical forest that makes archaeological research difficult - a detailed picture of the area was obtained with the help of a scanner, which made it possible to discern the remains of buildings and the road network of a part of the city hidden by forests and dense vegetation	The discovery of a previously unknown city the North of Ankor - Makhendraparvat, founded much earlier.
Belize	Caracol, ancient Maya archaeological site	Dense vegetation hid most of the city, which became “visible to archaeologists”	The plan of Caracol with traces of a dense network of roads and areas on the landscape of 200 square kilometers was obtained. Without the use of a scanner only 20 square kilometers of Caracol were investigated by archaeologists
Egypt	The Giza Plateau the location of the pyramids of Egypt	Mapping the environs of the Giza plateau and restoring the picture of the network of ancient settlements in desert conditions	The maps of settlements of antiquity on the Giza plateau
Ireland, Boyne Valley	Kurgan row with burials and shrines	The detection of previously unknown hills - possible new burial sites and shrines	The acceleration of the research process of the landscape and the identification of kurgan rows in the relief due to high scanning accuracy
Germany	Schwarzwald	A detailed study revealed 3000 archaeological objects, while aerial laser scanning provided information on the presence of at least 36,000 objects	The expansion of the field of archaeological research and the discovery of previously unknown objects

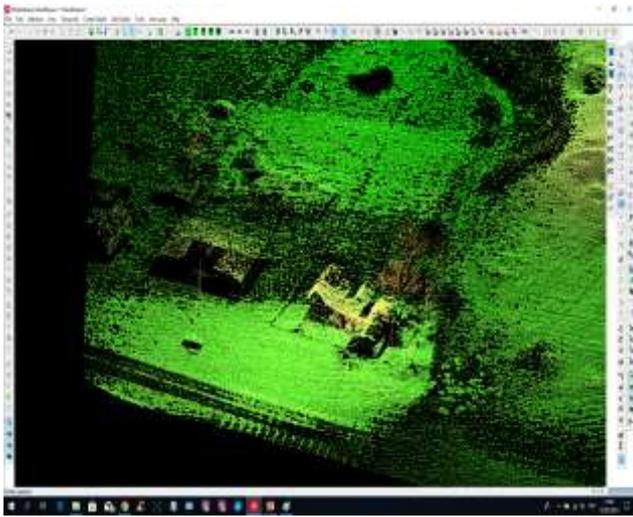


Fig. 2. Point cloud of scanned territory

III. RESULTS

The final results of the shooting of the Settlement are presented in Figures 3 - 7.

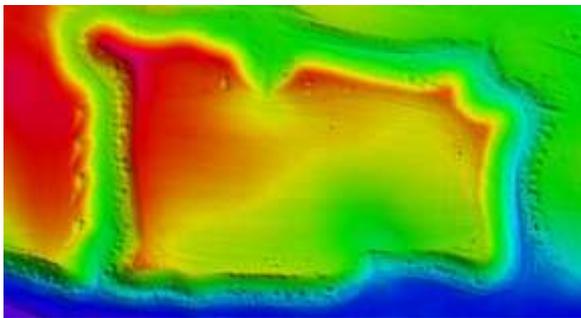


Fig. 3. Scanned Settlement

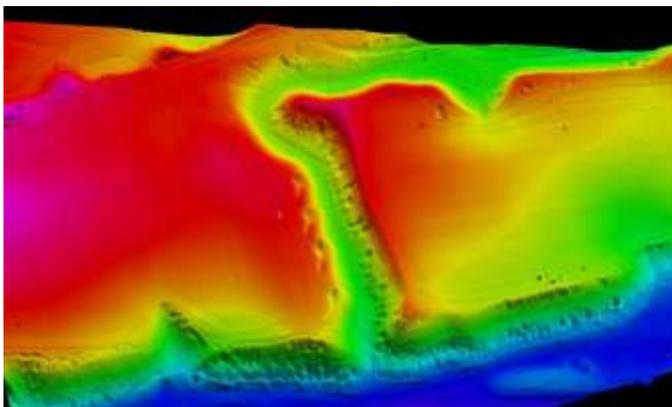


Fig. 4. Scanned settlement

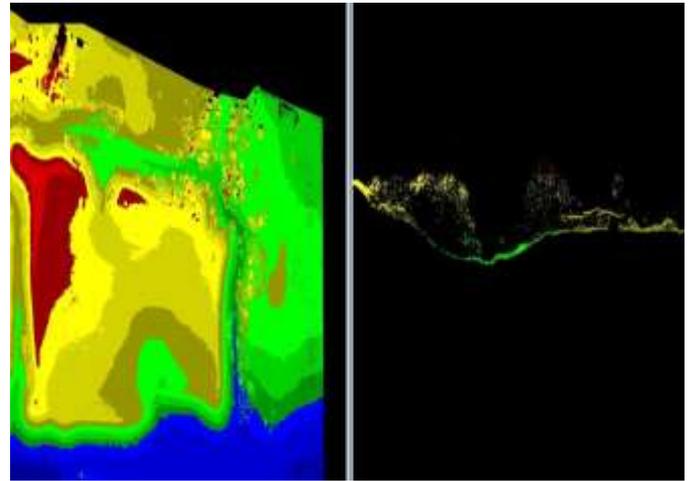


Fig. 5. Scanned Settlement

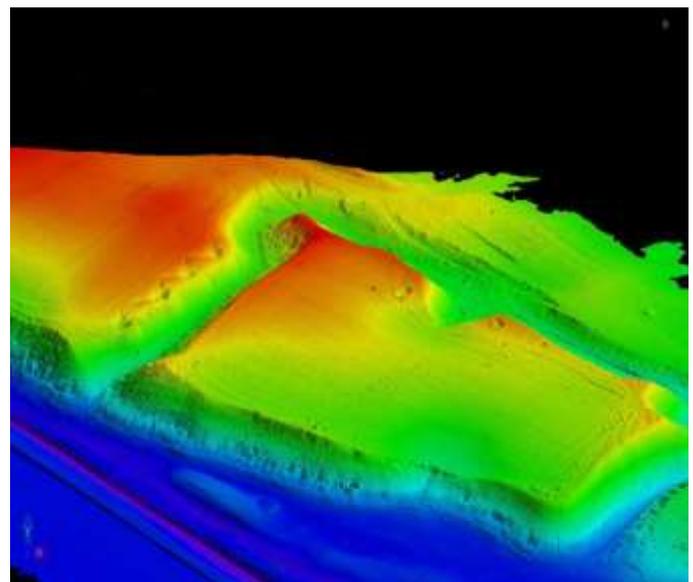


Fig. 6. Scanned Settlement

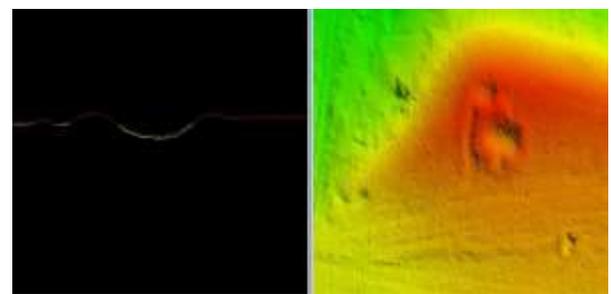


Fig. 7. Element of the Settlement found as a result of scanning

According to the analysis of global experience and the research of the authors on the Red October Settlement, the following main advantages of airborne laser scanning can be identified:

- the possibility to recognize and record the traces of archaeological objects (buildings, burials, ancient road and irrigation systems, etc.) in areas difficult for ordinary survey methods (tropical forests, hilly and mountainous areas, desert areas) [1];
- the acceleration of the production process of archaeological research due to the large area of coverage, high accuracy and detail of the resulting three-dimensional image using airborne laser scanning [6];
- Modern software products that provide automated classification of objects (vegetation, land, buildings, road network) also help speed up the process of field reconnaissance and the identification of characteristic objects (for example, the kurgan series, which may contain archaeological artifacts) [7].

Nevertheless, a number of researchers highlight the high cost of such a survey as well as the high cost of accompanying software for processing the results and building 3D-landscape models in an automated mode. They prefer another method of geodetic surveys, photogrammetric, arguing that low cost and ease of implementation, since in this case it is enough to have a high-resolution digital camera to get photographs and a personal computer with available software for obtaining a final three-dimensional model [5].

This type of research is relevant during the study of the features of the surface of individual archaeological monuments (strange vessels, separate burials) in order to exclude additional effects on archaeological objects, which may lead to their deterioration or violation of integrity and preservation. The use of airborne laser scanning seems to be more appropriate in case of the study of whole archaeological area that occupies large territory [1].

IV. CONCLUSION

Laser scanning, due to its high performance, established itself as one of the most advanced technologies for the implementation of high-precision imaging of various objects, ranging from small buildings to large landscapes. The scan results are applied in various fields, including archeology in

particular, for which this technique plays a significant role in speeding up the process of research with minimization of the risk of damage to the studied antiquities. It is important to note that the high cost of equipment and work is a significant obstacle to the implementation of laser scanning technology in archaeological work, but the solution to this problem can be found in government support in the form of targeted funded programs aimed at the identification and preservation of archaeological monuments and cultural and historical heritage sites.

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