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Hybrid Modeling of Adamkayalar Reliefs

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ABSTRACT

Throughout history, many civilizations with different ethnic and national values have lived in Anatolia. In many parts of Turkey's possible to encounter this civilization's cultural heritage. Cultural heritages in the world; until today, it has been affected by natural events such as earthquakes, floods and fire. These have been completely or partially destroyed as a result of human activities. Cultural heritage is very precious to people and assurance. Quick and practical documentation is of great importance to this. Various methods are used for this documentation process. Among these methods, terrestrial laser scanning (TLS) and Unmanned Aerial Vehicle (UAV) photogrammetry are frequently preferred techniques in recent years. Both methods ensure recording cultural heritages and producing 3D realistic models. It is not always easy to collect data in places with cultural value because of their historical importance and location. At this juncture, the use of terrestrial laser scanners and UAVs makes an important contribution to the documentation of cultural heritage. This study aims to examine the Adamkayalar reliefs, by using TLS and UAV photogrammetry. By processing the data obtained from both methods, a 3D model of the study area was produced and the results were evaluated.

1. INTRODUCTION

Anatolian geography, which has been home to different civilizations and cultures throughout history, contains numerous and different heritages that are historical, socio-economic and cultural. Providing clues about the life, traditions and customs of past societies, these cultural heritages are extremely important.

The studies conducted in recent years in Turkey gives weight to this issue (Ulvi et al., 2020; Ulvi & Yigit 2019). In this context, experts considering people's opinions and professional experiences, legal infrastructure (legislation) has been created. Laws, bylaws and regulations that have been enacted in the past and that are completely or partially out of date have been revised to meet the needs of the day (Çoruhlu et al., 2017; Koca et al., 2016; Aliefendioğlu & Tanrıvermiş, 2011; Ulvi et al., 2019; ÇŞB, 2006).

Efforts to identify, register, manage and preserve these cultural heritage works that mirror the past have gained momentum. The documentation has an important place in protecting cultural heritage and transferring it to future generations. These places; It is a field of study whose documentation includes different professional disciplines, since they were made in different periods and by societies with different cultures and characteristics. Therefore, the documentation process requires great dedication.

In the study, the TLS method was primarily used because it provides a fast and high-resolution method and enables the surface geometries of cultural heritage elements to be created effectively (Deniz et al., 2017; Ulvi & Yakar, 2014; El-Hakim, 2001; Barber et al., 2001) preferred. Scans were carried out to produce a 3D model of the work in question. With the point clouds obtained from this scan data, the 3D model was first created by this technique. As the second method; In addition to the TLS method, UAV photogrammetry was used in order to obtain more detailed information and to make the 3D model more comprehensive. Photographs of the reliefs in different areas in the region were taken with UAV overlapping. The 3D model of the heritage was produced by processing the data obtained from both methods.

Various methods were applied in the Adamkayalar relief of the study area, measurements were made, and photo-realistic 3D models of the area were created in a

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hybrid manner. In this way, a permanent document belonging to the study area was produced, and this is the historical monument; It has contributed to the transmission, protection, documentation and management of future generations. In addition, it is aimed to use the 3D model as a base for possible interventions to the work. Adding to the history and culture of this historic part of the national heritage register bears traces of civilization is of great importance for Turkey.

2. STUDY AREA

The working area, Adamkayalar BC. (before Christ) 3rd century. and the 3rd century AC. (after Christ). It is one of our cultural heritages, which is thought to have been built in the period between 6th and 15th. It is located in Şeytan Deresi Valley, which is approximately 5 kilometers away from the Kızkalesi District of Mersin Erdemli district. The Adamkayalar reliefs are located at 36 ° 31′30 ″ N 34 ° 03′15 ″ D coordinates (Kültür portalı, 2020).

The archaeological ruin known as Adamkayalar, which consists of large reliefs, is one of the important cultural heritage of Mersin city (Figure 1)

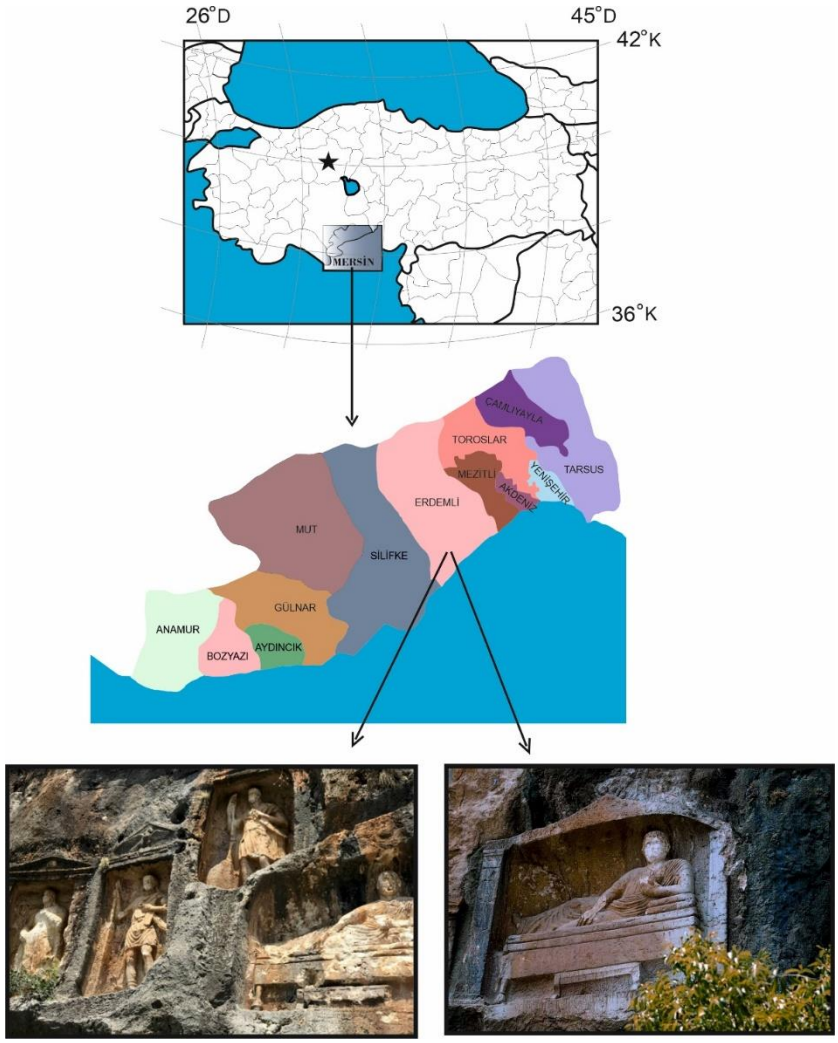


Figure 1. Study area

3. METHOD

Terrestrial photogrammetry has been used in 3D modeling of historical artifacts for many years, but it is insufficient alone (Uslu & Uysal, 2017; Chandler et al., 2007). In this study, 3D modeling of Adamkayalar reliefs, one of the national assets, was carried out by using TLS and UAV photogrammetry in the documentation of historical artifacts that are cultural assets. For this, a challenging field study was made, the work was created with a 3D model and the results were evaluated.

3.1. Terrestrial Laser Scanning (TLS)

The technique in which any object is scanned with the help of LIDAR (Light Detection and Ranging) technology is called laser scanning method (TLS). This technology is used in many fields such as cultural heritage recording, engineering projects and so on. LIDAR technology; it consists of 3 sections: terrestrial, air and mobile lidar. TLS method has become a technique that is generally used in research and studies for the protection and documentation of historical artifacts and cultural heritage (Beg, 2018).

In the documentation studies of national assets, 3D modeling is performed by triangulation method by using terrestrial laser scanners at close range during the

scanning of small sculptures, historical artifacts and objects (Sabuncu & Özener, 2020). In this method, the distance between the device and the object is measured and a point cloud is obtained thanks to the laser beam emitted from the laser scanner device, and thanks to this point cloud, a 3D model of the working area is created. This technology enables objects to obtain direct and precise 3D coordinates. Point position information is provided with high precision (mm) faster than conventional measurement methods.

In this study, Faro focus S 350 instrument was used as a terrestrial scanner. This device works according to the phase comparison method (Figure 2).

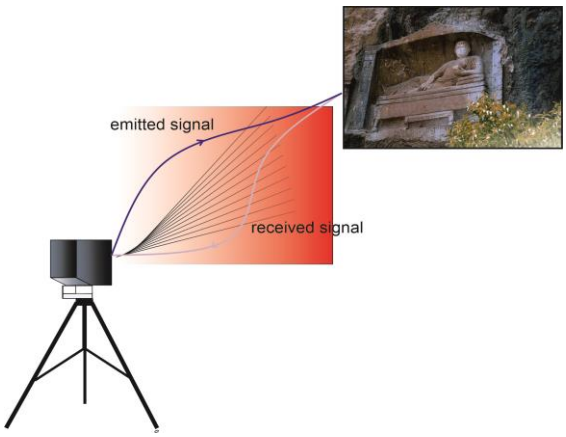


Figure 2. Phase comparison method

In the phase comparison method, the length of the object and the device is found by the phase difference between the reflected and emitted waves. The mathematical interpretation of the method is shown in Equation 1.

$$D = \frac{c*\theta}{4\pi f} \quad (1)$$

**D: distance*

**c: speed of light*

**f: frequence*

**Θ: phase difference*

3.2. UAV Photogrammetry

Today, in photogrammetry, the Structure from Motion (SfM) technique is mostly used in UAV photogrammeters (Sarıtürk & Şeker 2017; Furukawa & Hernández, 2013; Westoby et al., 2012). SfM is a method that aims to create a three-dimensional (3D) model from photographs taken with two-dimensional (2D) overlays (Snavely 2008; Dellaert et al., 2000). This method provides cost-effective work with high resolution large data sets (Kolzenburg et al., 2016; Morgan & Brogan, 2016) (Figure 3).

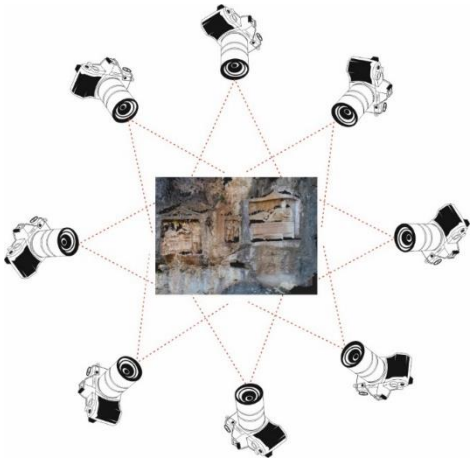


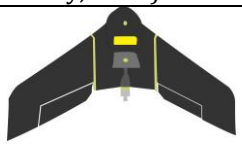
Figure 3. SfM method

The main purpose of the method is 3D model production (Çelik et al., 2020). Compared to other photogrammetric techniques, there is no need for additional camera calibration as the model geometry and camera position information are automatically resolved (Katarína et al., 2020; Simón et al., 2018).

The SfM technique was preferred in the study due to its various features and advantages in creating 3D models. With the development of technology in the documentation and permanent documentation of cultural heritage, the 3D model has become a powerful option. In this context, aerial photos were taken with the SenseFly eBee UAV in order to obtain general information about the historical place.

Table 1. SenseFly eBee UAV (Sensefly, 2020)

Weight	1.1 kg
Wing span	110 cm
Camera	senseFly SODA (20 MP)
Flight time	59 minute
Flight distance	45 km
Cruising speed	11-30 m/s



In order to better reveal the details of this work, which contains the traces of past societies, images were taken by the Parrot Anafi UAV.

Table 2. Anafi Parrot UAV (Parrot, 2020)

Weight	316 g
Camera	21 MP 4K HDR
Flight time	25 minute
Flight distance	4 km
Horizontal top speed	15.2 m/s
Vertical top speed	4 m/s

From these images obtained by UAV with different hardware and features, the 3D model of the work was created in the Agisoft Photoscan programme, a commercial software using the SfM algorithm.

First of all, the TLS method, which is a fast and high-resolution technique and has become widely used in the documentation of cultural heritage assets, was preferred. 8 scans were carried out around the Adamkayalar reliefs with a terrestrial laser scanner (TLS) at suitable seating places. A land survey was made before the study in determining the residence locations. Care has been taken to ensure that the reliefs appear at the optimum level and have common details with the next scan. The data were transferred in Faro Scene software, where laser scanning data can be processed and used in 3D model production. The point cloud of the study area was created and a 3D model was produced from this point data set (Figure 4). The process flow realized in the software is shown in Figure 4.

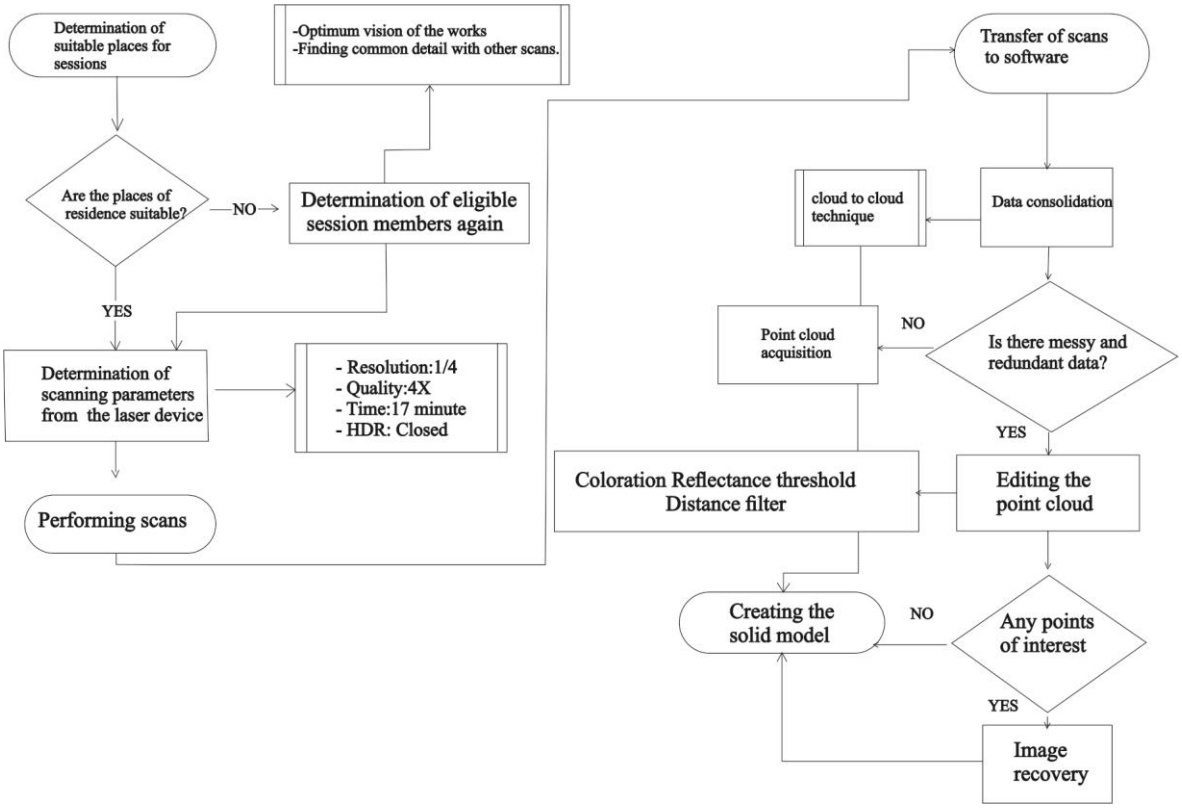


Figure 4. Process flow realized in software

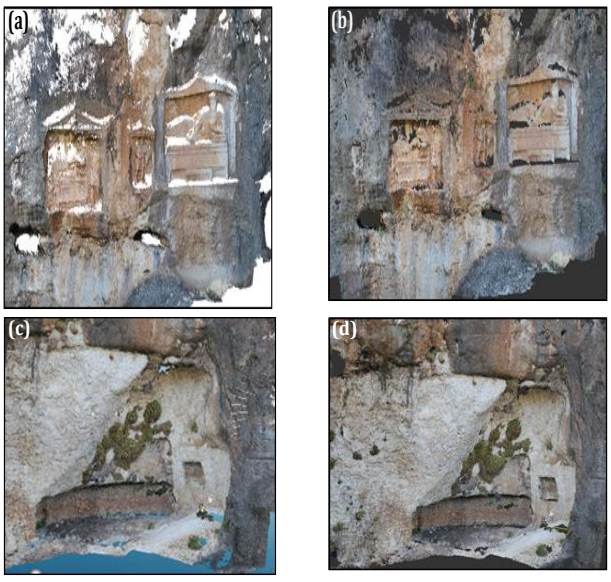


Figure 5. (a), (c) Point cloud obtained by TLS method (b), (d) 3D model

As the second method; UAV photogrammetry was used together with the TLS method in order to make the 3D model more detailed. Two different UAVs (Table 1, 2) were used in this method. First of all, the aerial (70 m height) images were taken with the eBee device in order to examine the study area as a whole and to obtain general information about the area. Then, photos were taken manually with the Parrot device in order to create clearly the facade and details of the reliefs in the 3D model. By processing the data obtained by both tools, point clouds and photo-realistic 3D models of the heritage were produced (Figure 7, 8).

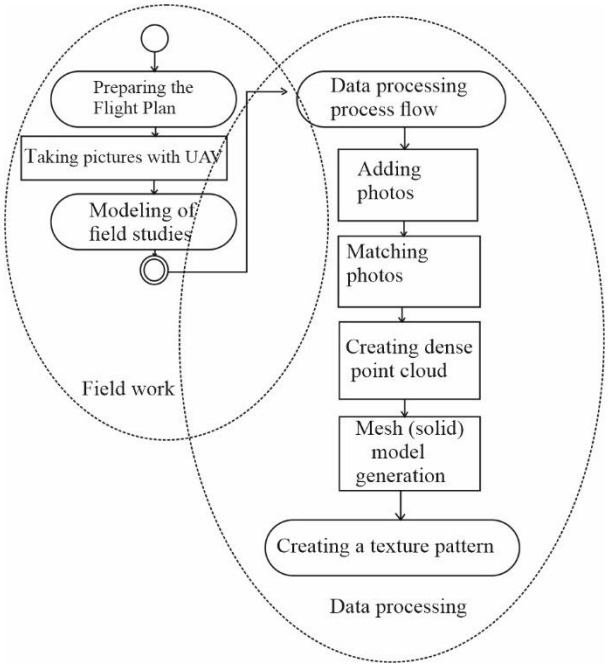


Figure 6. Processes in the UAV photogrammetry method

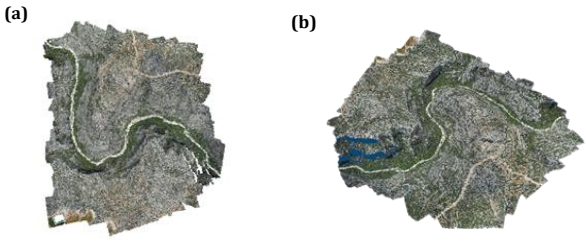


Figure 7. (a), (b) Point cloud obtained with SenseFly eBeee UAV 3D model

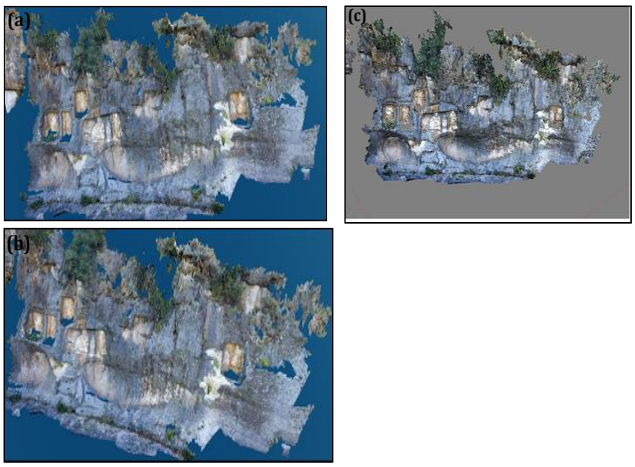


Figure 8. (a), (b) Point cloud obtained by Anafi Parrot UAV (c) 3D model

4. DISCUSSION AND CONCLUSION

The study area is the Adamkayalar relief, which has historical, sociological and cultural significance. In this heritage work, TLS and UAV photogrammetry methods, which have become widespread in documentation processes in parallel with the developing technological advances, were used. Although these techniques have advantages and disadvantages, each has its strengths.

With the work carried out, the positive and negative aspects of the techniques were tried to be determined. TLS method provides fast, high quality and resolution data in close range. In addition, accuracy and precision are extremely high. Thus, it has been determined that it is among the strongest alternatives that can be used in the documentation of cultural heritage studies. Although the positive features of this method are dominant, it also has some disadvantages. This method alone is insufficient for factors such as the relatively large size of the work or structure to be documented and the difficulty of access to the region.

The UAV photogrammetry method provides the opportunity to measure at close or far distances, without reaching the object. 3D model can be obtained directly or by means of point clouds by taking photographs of the object with overlapping. Within the framework of these features, this method can be used alone or in combination with different methods in the documentation of cultural heritage. This technique also has negative aspects. While the aerial view of the work to be modeled can be obtained easily, in some cases, facade photographs cannot be obtained properly. This problem causes the side surfaces and details to not be fully formed in the model of the work. In addition, it is not always possible to benefit from UAV photogrammetry due to factors such as the geography and geopolitical location of the study area. In order to eliminate the aforementioned negativities, integrated transactions are carried out with different methods.

In the study; Different methods were applied, measurements were made, and photo-realistic 3D models of the field were produced in a hybrid way. In this way, a permanent document belonging to the working area has been created. The historical work of this document; It is predicted that it will contribute to the transmission, protection, documentation and management of future generations. In addition, it is highly possible to use the 3D model as a base for possible interventions to the work. It is assumed that this study is important for adding this historical region bearing the traces of past cultures and civilizations to the national heritage records and can set an example for other similar studies. Located preservation of numerous cultural heritage waiting to be unique and discovered in Turkey, although tourism and therefore the documentation of the cultural heritage in terms of making contributions to the promotion of the country is extremely essential that the process should be made by those skilled in the area.

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