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UAV Based 3D Modeling of Ancient Quarry Nearby the Göbeklitepe

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Keywords

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ABSTRACT

Documentation of historical artifacts and archaeological sites is a very important process in terms of preserving cultural heritage. Because such cultural heritages that should be passed on to future generations are destroyed or even disappeared over time. The documentation process is a versatile multi-disciplinary process. Today, methods in the documentation process started to change with the developing technologies. In recent years, image-based 3-dimensional (3D) modeling by using Unmanned Aerial Vehicles (UAV) has also been widely used. In this study, UAV based 3D modeling of an ancient quarry located on a hill relatively close to Göbeklitepe and the produced topographic products such as digital elevation model and orthophoto are presented.

1. INTRODUCTION

The Unmanned Aerial Vehicle (UAV) platforms are very important data source that enables inspection, surveillance and analysis for different disciplines and different application areas in photogrammetric data production. These systems, which have been used since the 1960s, are getting more and more attention from scientists and researchers. The main reason for the increasing popularity of UAV systems is that thanks to the developing photogrammetric sensor, platform, and remote sensing technologies, they provide higher spatial and temporal resolution compared to classical aerial photogrammetry (Kaya et al., 2019; Ulvi, 2018; Uslu et al., 2016). Also, this method has significant speed and low-cost advantages in photogrammetric data production. Provided by the UAV systems, it has many civil and commercial applications due to the advantage of fast and economical access to up-to-date data (Yakar et al., 2016; Kaya et al., 2019; Remondino, 2011). Today, it is used in different disciplines such as agriculture, archaeology, forestry, wildlife research, geomatic engineering, habitat studies, landscape planning, mining, environmental surveillance, natural disasters, traffic management, transportation, energy, geology (Vacca, Onishi, 2017; Näsi et al., 2018; Calleja et al., 2018; Bagaram, 2018;

Onitsuka et al., 2018; Azhari et al., 2017; Tziavou et al., 2018; Toprak et al., 2019, Ulukavak et al., 2019).

There are many studies on the use of UAVs in photogrammetric modeling and mapping. These studies mostly involve the production of orthophotos, point clouds and DEMs (Uysal et al., 2015; Polat, Uysal, 2018). Some studies also have rock relief modeling (Toprak et al., 2019). Similar applications are also made in open minefields. Especially at actively used mines, UAV systems are used in operations such as determination of production and stripping amount, stock and dump area cubage calculations, rock detection, geological mapping (Muammer et al., 2017). UAVs, also have been used widely in the documentation of historical artifacts and archaeological sites in recent years. In this study, an UAV based modeling of an ancient quarry located on a hill which is very close to the Göbeklitepe archaeological site is presented.

2. METHOD

In the study, TurkUAV Octo V3 UAV was used to produce an orthophoto of the archaeological site. The images obtained with the UAV were processed with Agisoft Photoscan, a very popular, photogrammetry software.

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2.1. Study Area

The study area is on another hill about 3km away from the Göbeklitepe archaeological site. Although the ancient quarry is mostly covered with soil, the linear rock cuts and room like parts are obvious. The location of the study area with the Göbeklitepe is given in Figure 1.



Figure 1. An aerial image that shows the Ancient quarry and Göbeklitepe locations

2.2. Equipment

The study was performed with TurkUAV Octo V3 UAV as a photogrammetric platform. The weight of the UAV is approximately 8kg and the payload is a maximum of 3 kg. Flying time depends on both battery and payload weight. A lot of features of this model are available such as Altitude Hold, GPS Hold, CareFree, Coming Home, Fail-Safe, Low Battery Protection, Auto Take-Off and Landing, Waypoint Flight. Mikrocopter (MK Tools) software lets us view the navigation and flight status information in real-time. It is possible to perform an autonomous flight plan over the online basemaps. Moreover, some details such as horizontal and vertical speed, altitude, direction, waiting time at willing points, coordinate information, and camera angle are also can be specified. Waypoint Flight electronic is capable of autonomous flight in a 1000m radius area and 250m fly height for a standard route. The digital camera was a Sony RX100 MII. It has been featured with a 20.2 Megapixel and 13,2x8,8mm CMOS image sensor. Single, continuous, and self-timer drive abilities are among the digital camera features. The Bodyweight of the device is 281g. An image of the unmanned aircraft and the camera are shown in Figure 2.

Multiple parameters should be taken into consideration when working with UAVs. First, the flight plan should be done well and the scenarios of any errors that may arise should be reviewed carefully. The weather conditions (temperature, pressure, humidity) at the time of flight of the region should be checked. To identify the obstacles that may be encountered in the area where the flight will take place, it is necessary to check the dangerous high objects on the land by going to the area before the flight. A flat surface should be chosen as far as possible for the UAV to be able to take off smoothly. Before starting the flight, pre-flight preparations should

be checked step by step and then the flight should be started.



Figure 2. The UAV system and Digital camera

3. RESULTS and DISCUSSION

Since the working area is wide, two different flights were carried out. As a result of these flights planned from an average height of 60 m, a total of 917 photographs were obtained. The ground sampling interval of the photographs was calculated as 1.33 cm. The total area covered by the photographs is approximately 0.169 km². Photogrammetric flights made with 80% transverse and longitudinal overlap. Camera locations and image overlap is given in Figure 3.

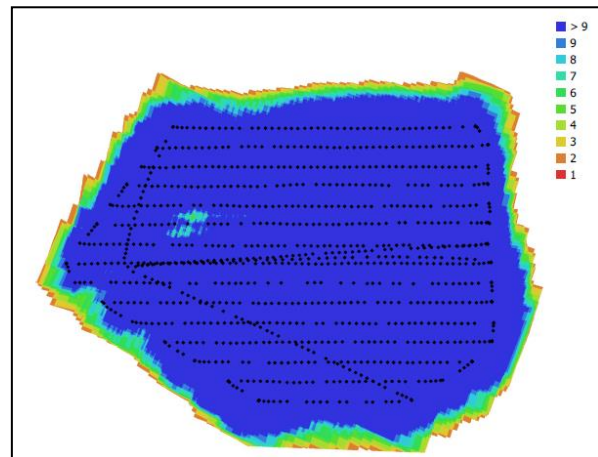


Figure 3. Camera locations and image overlap

The obtained geotagged photos were processed with Agisoft software. Aproxiamtely 62 million points were obtained from the photographs. These points were used in the production of a high-resolution digital elevation model and orthophoto of the land surface. The produced model and orthophoto are shown in Figure 4.

When the study area is examined in more detail, it is seen that the stones in the region are linearly cut (Figure 5). The proximity of Göbeklitepe reminds us that stones were removed from here during the construction of the area.

It is also observed that irregular new excavations were made in the area. Since the area is known to be close to a site like Göbeklitepe and does not have an

active quarry, it is thought that randomly irregular excavations were carried out in this area to search for treasure. Images of the excavated areas can be seen in Figure 6.

At the end of the study, a 3D model covered with a true color texture of the entire region was produced. This model can be used in different environments such as virtual reality or GIS with different export options. A few examples of the model are given in the view Figure 7.

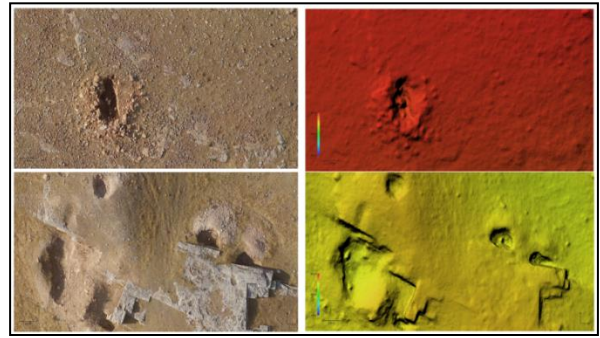


Figure 6. Excavated areas for treasure search

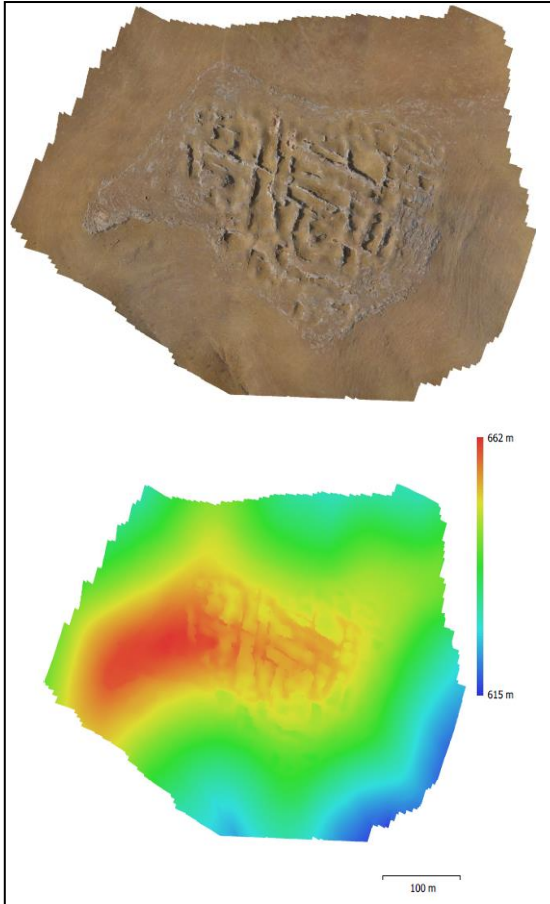


Figure 4. Reconstructed digital elevation model and orthophoto



Figure 7. Scenes from the generated 3D model of the ancient quarry

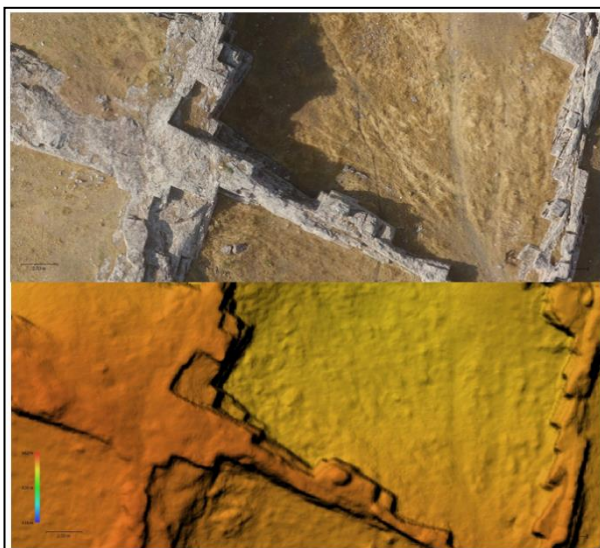


Figure 5. Linearly cut stones

4. CONCLUSION

UAVs are very important platforms because they are portable, useful, and cheap. Tenders used in many application areas today can also be used in 3D modeling of open minefields. Within the scope of the study, a historical stone quarry was modeled using an UAV flight. It is also important that the region is close to Göbeklitepe. Because when the model produced with high resolution was examined, it was seen that new excavations were made in the region, which was thought to be for treasure purposes. In this context, changes occurring in such regions can be observed regularly with tenders.

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