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Excavation monitoring with UAV in Şanlıurfa Castle archaeological site

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ABSTRACT

There are many archaeological sites in the world from past civilizations. These areas, which are cultural heritage sites, have suffered severe destruction and deformation because of humanitarian interventions such as earthquakes and floods or wars. These demolitions and deformations continue today. Therefore, archaeologists try to document all objects of potential value that they uncover as a result of excavation. Documentation is also necessary for the identification and interpretation of the found objects, as well as for restoration and reconstruction, which are possible after archaeological excavation. For this reason, the documentation process is as sensitive as possible, without damaging the objects and requires the correct way. At this point, recently, fast and practical, very high-resolution images, low cost and repetitive use due to the unmanned aircraft (UAV) began to be preferred in documentation studies. In this study, UAV usage is given in the archaeological excavations of Urfa Castle.

1. INTRODUCTION

Historical artefacts are cultural legacies that hosting Many hundred years of knowledge. This knowledge must be transferred to the next generations. These historical heritages reflect the life-style and aesthetic understanding of elder civilization as well as being cultural assets that hosting all changes in time such as wars and earthquakes. The documentation and conservation of the natural tissues of historical monument without damaging is indispensable element for transferring future generations. It is a fact that cultural heritages not only in our country (Turkey) but also in many parts of the world were damaged and being damaged. Because of this reason cultural heritages are partly documented in time all over the world.

The work of documentation of historical places and cultural heritages is complex and multi-faceted process (Kulur, 2005). Documentation of historical or cultural structure covers the entire steps which is necessary for determining current state of the structure (shape and position) in three-dimensional space that are surveys, process, storage and presentation (Georgopoulos and Ioannidis, 2004). There are a few techniques for documentation of cultural heritages (Bohler and Heinz, 1999). These techniques, which are very important and necessary, are traditional surveys, topographic techniques, photogrammetric surveys and scanning technique (Bohler and Heinz, 1999, Scherer, 2002). At this point, it is a huge advantage that photogrammetry can provide reliable information in a short time (Yakar and Yılmaz, 2008; Şasi and Yakar, 2018).

Nowadays, with the remarkable advancement of Computer Vision and Photogrammetry, the image-based modelling becomes as a rival for laser scanning (Remondino et al., 2011). Some remarkable advantages of image-based modelling are that: it is low cost and contains colour information; any kind of camera (calibrated or un-calibrated) can be accepted (Colomina et al., 2008) and it may produce point cloud denser than a laser scanner. This image-based approach, named as Structure from motion (SfM) is a newly popular low-cost Photogrammetry method com-pared to its competitors.

During the last few decades, low-cost Unmanned Aerial Vehicles (UAVs) are used as an

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alternative photogrammetric platform for traditional data capture, especially while aiming at mapping application with high spatial and temporal resolution and introduces also a low-cost alternative to the classical manned aerial Photogrammetry (Colomina et al., 2008; Eisenbeiss, 2009; Ulvi and Toprak, 2016). Nowadays, the use of UAVs is increasing day by day due to its advantages at cost, inspection, surveillance, reconnaissance, marine environment, and mapping (Remondino et al., 2011; Bayirhan and Gazioğlu, 2019; Gazioğlu et al., 2017; Akar, 2017). In this study UAV platform is used to capture aerial images of Sanliurfa castle in purpose of producing a template for planning excavation by archaeologists.

2. STUDY AREA AND EQUIPMENT

The study is at inner city of Şanlıurfa (Figure 1). The castle was built by the Osroene in antiquity and the current walls were constructed by the Abbasids in 814 AD.

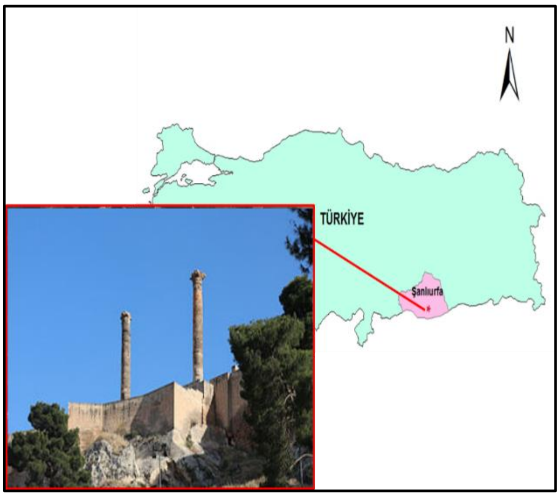

Figure 1. The Sanliurfa castle (37° 8'43.95"N, 38°47'2.45"E).

The TurkUAV Okto V3 was used to capture images (Figure 2). It uses the microcopter electronic. The weight of it is approximately 6 kg and the payload are 3 kg. Flying time essentially depends on both battery and payload weight. A lot of features of this model are available such as Waypoint Flight and Follow Me. Mikrocopter (MK Tools) software let us to view the navigation and flight status information in real time. It is possible to perform autonomous flight plan over the online maps. 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 2km radius area.

The digital camera was Sony RX100II (Figure 2). It has featured with 20 Megapixel. Single, continuous, and self-timer drive abilities are among the digital camera features. The Body weight of the device is 281 g. All images are processed in Pix4D software.

Figure 2. The UAV and Digital Camera

3. METHODOLOGY

Although the SfM approach is developed by the computer vision community in order to get an automatic feature-matching algorithm, yet it operates under the same essential conditions as Stereoscopic Photogrammetry (Tanskanen et al., 2013; Snavely, 2009; Westoby, 2012; Micheletti, 2015). The overlapping images are used in order to get a 3D form of interested object.

However, there is a fundamental difference between traditional Photogrammetry and SfM. In traditional Photogrammetry, 3D position of the camera(s) or 3D position of ground control points (GCP) have to be known to determine the 3d location of points within an image. In contrast, the SfM determines the geometrical parameters (orientation, internal and external parameters) automatically without any pre-defined set of known GCP (Westoby, 2012). Instead, these parameters are solved synchronously using a highly overlapped image set with automatic identification of matching same features (Snavely, 2009).

Then, an iterative non-linear least-squares minimization process estimates the camera positions and object coordinates by tracking matched features image to image. Comparing with the traditional Photogrammetry, the determined camera positions are in the image space, which means there is no scale and orientation, considering the object space. This issue can be overcome with a 3D similarity transformation by using a small number of GCPs (Westoby, 2012). To get a useful 3D geometry of the object, the images must fully cover of the object, which means the camera captures the images from different positions by means of moving, as the named structure from motion (moving sensor) in the scientific literature.

4. APPLICATION

The study performed in two flight. The first flight covers the entire castle to get a wide view of the study area before the excavation. With the first flight, the initial base orthophoto is generated. The second flight is performed a few weeks later.

Meanwhile, the excavations started. The aim of the second flight is to observe the progress of excavation. So, the area of second flight covers only east part of castle where the excavation starts. The basic information's about flights are given in the table 1.

Table 1. The basic information's about flights

	Flight 1	Flight 2
Dataset	147 images	319 images
Covered Area	0.11 km2	0.03 km2
GSD Average	2.19cm	0.95 cm
Column	6	Grid flight
Points	17784677	30665936
Density (per m3)	226.3	3531.15

The Grid flight consists of two flight plane that are perpendicular to each other. This type of flight is very successful to create 3D models of the earth's surface. The generated point cloud for both flights is in figure 3 and 4.

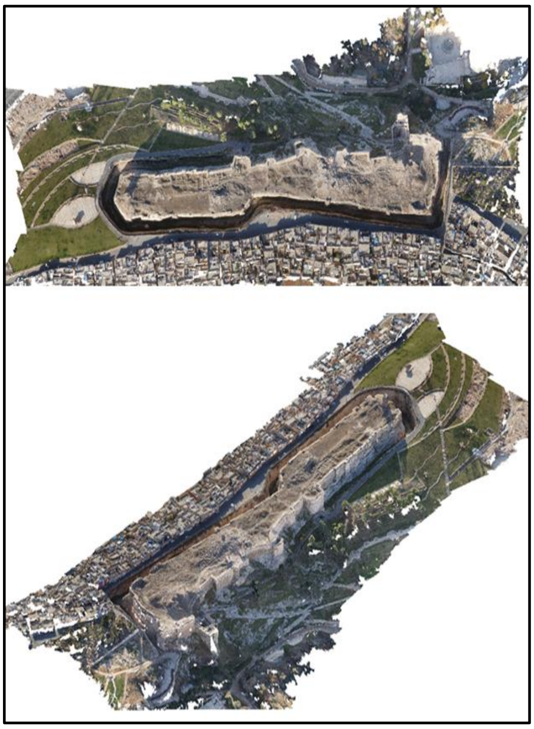

Figure 3. Point cloud of the first flight

Figure 4. Point cloud of the second flight

The excavation was started at the east side of the castle where the entrance exists. Therefore, to observe the progress of the excavation, a cloud to cloud distance calculation was performed (Figure 5).

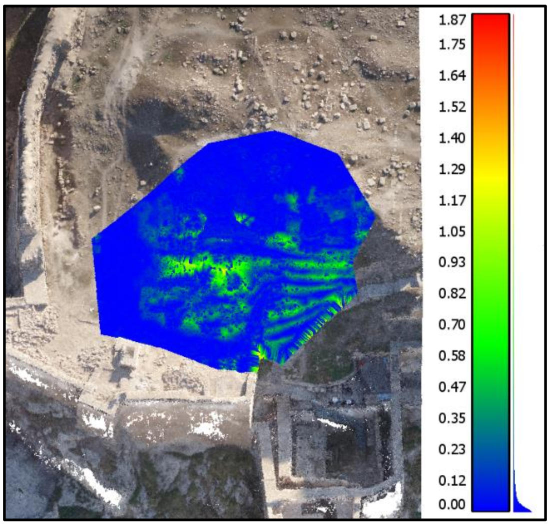

Figure 5. Cloud to cloud distance calculation

According to this calculation, there are height differences in excavation area from 10 cm to nearly 2 m. Unfortunately, the study area was closed to prevent the risk of collapsing due to heavy rainfall. Therefore, a control terrestrial measurement could not be made.

As a final analysis, an approximate volume calculation is performed. In this analysis, the first point cloud is used as base/initial state and the second point cloud used as final state of the area. In the end, the approximately added and removed volumes were calculated as 10,9 and195,4 m^3 respectively in an 816 m^2 surface area.

5. CONCLUSION

This paper depicts the possible usage of UAVs in archeological studies. The generated products of this study such as orthophoto, point cloud or digital surface models can be used in archeological studies. In our case the generated orthophoto was used in determining the current status of the castle and planning the archeological excavation. the generated Point clouds were used for approximate volume calculation. The study shows that, UAV and photogrammetry have advantages and wide capability of usage in arkeological studies in terms of cost, time and temporal usage.

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