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3D model of Üçayak Ruins obtained from point clouds

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ABSTRACT

Historical artifacts are in danger all over the world as they are being damaged continuously. In order to transfer them to future generations and restore them, we need to create digital products of them. The developments in remote sensing allow us to model objects in computer environment. In this study, a cultural heritage located in Mersin was modelled in 3D using an unmanned aerial vehicle (UAV). Circular mission plan in the mobile phone application was preferred. Overlapping pictures were aligned. Digital surface model, orthophoto and 3D model of Uçayak Ruins have been created. Aerial photogrammetry allows us to create digital products in a short time. The obtained model will be used in tourism advertisements.

1. Introduction

Turkey has hosted many civilizations throughout history. Turkey has been preferred for settlement because it is surrounded by the sea on three sides, is located on migration routes and has fertile agricultural lands. Assyrians, Byzantine, Seljuk and Ottoman Empires have lived in this territory. These civilizations have left us cultural legacies. As a result, Turkey has a deep history of geoarchaeological sites.

Mersin City, located in the southern parts of Turkey, has a great potential for archeological studies (Alptekin and Yakar 2021). There are many archaeological study areas such as Kızıkaiesi, Olba Ancient City, Anemurium, Heaven Hell Potholes and Uzuncaburç. They are being negatively affected from natural and anthropogenic effects.

Geopark turizm has been gaining importance since last decade. Geoparks occur with the process of million years. Mut Miocene Basin is one of the candidates Geopark sites in Turkey. Moreover, it has canyon, valley, and waterfall in it. Geoparks are open air laboratories to describe geological events.

Agriculture and tourism are the main incomes of Mersin. Geo-tourism is important for rural

development of Turkey (Kocalar, 2020; Varol et al. 2021). However, Mersin is experiencing a lack of publicity.

Historical artifacts are important sources that enable us to reach the life information of the past (Yakar et al. 2005; Yakar et al. 2010). However, they are being damaged due to the unconscious behaviors of people, treasure hunters, natural disasters and climate changes (Ulvi and Yakar, 2010). We need to document our cultural heritage in the computer environment, in order to pass it on to future generations, use it in tourism and restore it in the future (Yakar et al. 2016).

Terrestrial laser scanner (TLS) and unmanned aerial vehicle (UAV) have been used to model the archeological sites in 3D since last decade. Alptekin et al. 2019 have used TLS to model the mausoleum in Kanlıdivane.

In this study, Üçayaklı ruins located in Erdemli province of Mersin city was modeled using a UAV. Üçayaklı ruins, also called villa rustika, was the residence of the great landowners during the Roman and Byzantine periods. The walls of the building, which has been well preserved until today, are intact. However, the ceiling and floor, which was made of wooden, were demolished (Çalışkan et al.2009). The

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second floor has large windows and consoles that prove the presence of a balcony, while the first floor has small windows (Fig.1).



Figure 1. Uçayak ruins

2. Study area

Mersin is located between Mediterranean Sea and Taurus Mountains. The study area is located in Erdemli District, Mersin Province (Figure 2). Uçayak Ruins is between Küstülü and Hüsametli villages. Total distance to Mersin city center is 65 km.



Figure 2. Location map

3. Methods

UAV has been frequently used in engineering projects since last decade. UAV has been used in agriculture (Bendig et al. 2014; Şenol et al. 2021), culture heritage modelling (Şasi and Yakar, 2018; Ulvi et al. 2019; Sarı et al. 2020), mapping landslide area (Al-Rawabdeh et al. 2017; road extraction (Yiğit and Uysal, 2021), shoreline change detection (Unel et al. 2019), pond volume measurement (Alptekin and Yakar 2020).

Obtaining accurate and complete data will increase the accuracy of the documentation work (Hamal et al. 2020). Visual and scientific applications of 3D modelling have a great role in documentation of cultural heritage (Yılmaz et al. 2008). Terrestrial photogrammetry is not able to take pictures from the roof of the structure. Aerial photogrammetry will solve this problem. Therefore, aerial photogrammetry will be selected in building modelling projects.

There are many softwares such as Agisoft, ContextCapture and Photomodeller that can model the object in 3D. Kabadayı et al. 2020 have discussed the advantages and disadvantages of these softwares.

In this study, Anafi Parrot (Figure 3) has been used to take pictures of cultural heritage. Technical properties of Anafi Parrot is given in Table 1.



Figure 3. Anafi Parrot

Table 1. Technical properties of Anafi Parrot

Property	Value
Drone weight	320 g
Controller weight	386 g
Battery weight	126 g
Max. flight time	25 min
Max. horizontal speed	15.2 m/s
Max. vertical speed	4 m/s
Max. wind resistance	13.9 m/s
Max. transmission range	4000 m
Max. altitude	150 m
Operating temperature range	-10 C° to 40 C°
Camera	21 MP
Resolution	4608x3456
Focal length	4 mm
Pixel size	1.34 x 1.34 µm

Pix4Dcapture, a cell phone application, has been used to prepare circular mission flight plan. The flight height was 30m and GSD was 3.87 cm/pixel. Circular mission plan is used to take pictures of an object with 3D. In this study, 107 overlapping pictures were taken (Figure 4). The pictures were processed in Agisoft Metashape software 1.5.0. The steps is shown in Fig. 5.

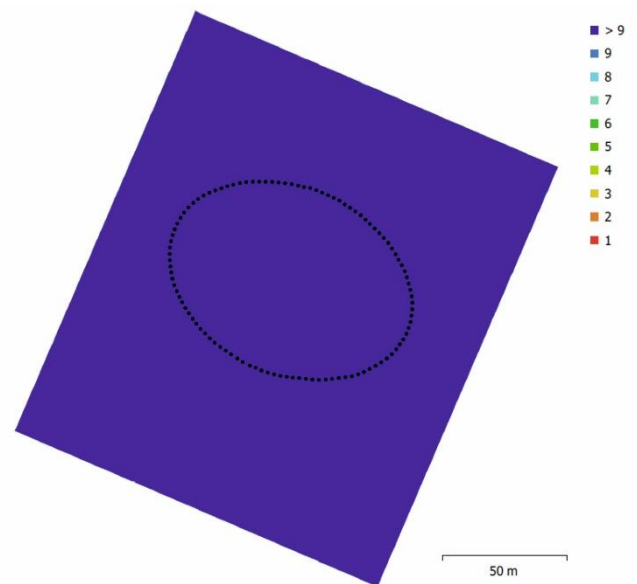


Figure 4. Camera locations

- Add Photos
- Convert coordinates of photos
- Align Photos
- Build mesh
- Add ground control points
- Input marker coordinates
- Optimize camera
- Build dense cloud
- Build mesh
- Build texture
- Generate orthophoto
- Generate DSM

Figure 5. Process steps

To georeference the study area, four ground control points were used. Coordinates were taken by using a GPS with one epoch. Error amounts are given in Table 2.

Table 2. Error amounts of ground control points

Direction	Error amount (mm)
X error	6.19458
Y error	3.87626
Z error	4.81898
XY error	7.30741
Total	8.75333

4. Results

In this study, 3D model was created with medium quality (Fig 6). High quality model needs high standards of computer. Moreover, pictures taken from close-range will increase the resolution of the model.

DSM (Fig. 7) and orthophoto (Fig. 8) of the study area were created. The elevation of the study area is between 906 and 928 meters. Orthophoto has too many white holes because of circular mission flight plan.



Figure 6. 3D Model

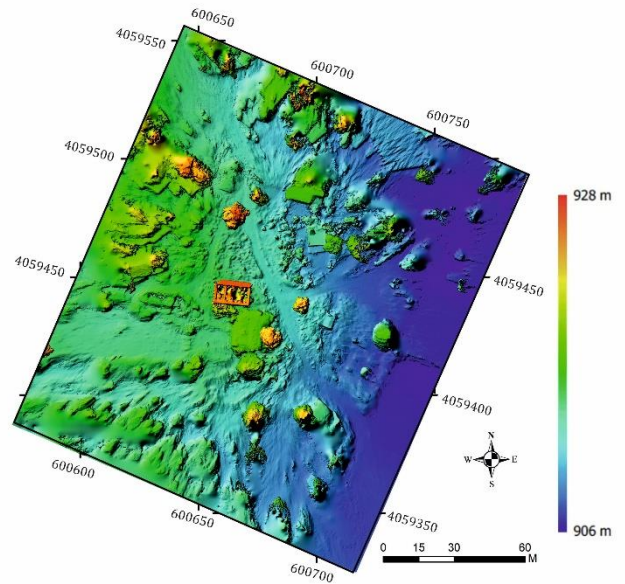


Figure 7. DSM

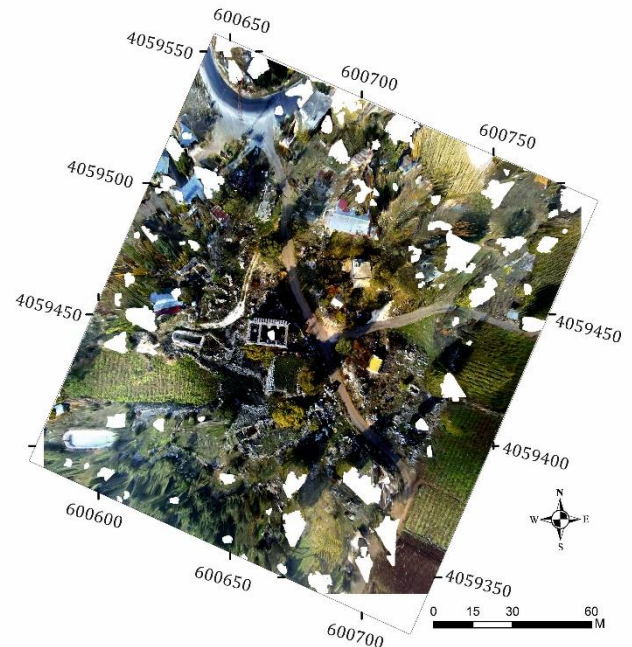


Figure 8. Orthophoto

5. Discussion

It is very important to transfer historical artifacts bearing the signatures of world history to future generations (Yakar et al. 2015). Along with the developing technology, the classical method of documentation has now been replaced by modern documentation techniques, which has led to the rapid advancement of contemporary documentation techniques (Korumaz et al. 2011).

In today, modelling of a cultural heritage is being performed with using a UAV. The pictures will be taken manually with a UAV. Overlapping pictures will be aligned with the help of tie points. The quality of the model will be increased when high quality aligned mode is selected.

Circular mission plan is an alternative to manually taken pictures. It will be used easily in Pix4Dcapture mobile application.

6. Conclusion

Historical artifacts are in danger all over the world. Turkey has an ancient history. Too many civilizations have lived and left us precious cultural heritages. Documenting historical artifacts is vital to transfer cultural heritage to future generations. Modern technology allows us to create 3D model of the object with high accuracy in a short time. In this study, the model of Ucayak Ruins has been created in 3D. This model will be used in tourism advertisements.

Author contributions

Aydın Alptekin: Literature review, Field study, Modelling, Writing; **Murat Yakar:** Editing

Conflicts of interest

The authors declare no conflicts of interest.

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