Modelling of its surroundings and Selime Cadhetral by UAV data

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Abstract
Historical and cultural heritages are the common values of all humanity. They are rare works that contain traces of the religious, cultural and social lives of human beings from the past to the present. It is important to pass them on to future generations. For this reason, documentation and restoration studies of such heritages are also important in terms of human history. Documentation studies can be done with traditional methods, as well as with Unmanned Aerial Vehicles (UAV) data, in a fast and sensitive way. In this study, three-dimensional modeling studies were carried out on the UAV data of the Selime Cathedral, the largest cathedral of Cappadocia. Documentation of such cultural heritages and obtaining three-dimensional models are considered important both for the sake of preserving the heritage and for viewing it visually in the virtual environment under appropriate conditions.

1. Introduction

Unmanned aerial vehicles (UAV) systems and applications are increasingly used by many institutions, organizations, commercial enterprises and academic circles for different purposes. In parallel with the increase in land use, management and monitoring studies, the need for location-based information is constantly increasing day by day. By using modern terrestrial, air and satellite-based technologies, the data needed together with Geographic Information Systems are collected, analyzed and results can be presented in various ways more quickly and accurately than ever before [1]. In the last decade, too many engineering projects have been solved using UAV. Pond volume determination [2], landslide site [3-5], rockfall site [6], cultural heritage modelling [7-13] and soil erosion [14] are the most commonly usage area of UAV.

One of the methods adopted in order to obtain the spatial data needed in recent years is the use of UAVs. A UAV is a vehicle that can move automatically or semi-automatically depending on a flight plan, or is flown by remote control by a pilot on the ground or in another vehicle. UAV-based data collection and mapping can provide sufficient accuracy needed in many fields such as agriculture, forestry, urban planning, and disaster management.

Depending on the carrying capacity and features of the UAV platform, it can be equipped with video cameras, thermal or infrared camera systems, multispectral cameras, LiDAR sensors or a combination of these technologies. In addition, the UAV may include GNSS/INS (Global Navigation Satellite System/Inertial Navigation System) system, barometric altimeter and compass systems. Such an integrated system is often referred to as an Unmanned Aerial Vehicle System (ISP).

There are various methods such as Global Positioning Systems (GPS), terrestrial geodetic surveys, LIDAR, terrestrial laser scanner, conventional aircraft, photogrammetry and remote sensing that produce location-based data. It is a technology that can produce accurate and sensitive data based on location in UAV. UAVs will be the most important data source generating data for many disciplines in the future [15].

UAVs are vehicles that can fly continuously automatically or semi-automatically according to aerodynamic flight principles, and move without a flight crew (pilot). The UAV can fly in remotely controlled, semi-automatic or fully automatic techniques and can carry cameras, sensors, communication equipment or other equipment. UAVs have a much smaller structure than conventional manned aircraft, so they are much easier and more economical to transport [16]. On the other hand, real-time kinematics (RTK) positioning systems can be attached to UAVs, and thus images with more precise location information can be obtained.

A three-dimensional (3D) model should be used in applications such as virtual reality, communication, and automatic orientation. For example, during industry quality assessment, it is important to create a 3D model of buildings before and after a disaster, in tourism, architecture and 3D urban planning. In such studies, UAVs are used very effectively and efficiently [17].

There are many internal and external factors that cause the deterioration of cultural heritages until today [18-19]. These artifacts have survived to the present day by being exposed to many negative factors such as negligence, destruction by people, war, earthquake, fire, flood, etc [20-22]. For this reason, it is very important that the cultural heritages that can be preserved, which cannot be reproduced and cannot be returned, have to be documented in a non-destructive way down to the smallest point [23].

Photogrammetry, with the latest developments, offers the opportunity to take pictures with UAV. This facility allows fast and economical 3D modeling of objects on the earth's surface with the help of photographs taken by the UAV [24]. This provides the opportunity to reach even the most difficult point that is difficult to reach. Different photogrammetric approaches have been used to create 3D models [25]. There are many studies on this subject in the literature. 3D modeling studies find application in many different areas. The 3D model creation studies also form the basis for the documentation and protection of cultural heritage and survey studies when necessary. In this study, 3D modeling studies of UAV data of Selime Cadet, the largest cathedral of Cappadocia, were carried out.

2. Application

Selime Cadet located in Selime town of Aksaray province was chosen as the application area (Figure 1). Selime lived the Hittite, Assyrian, Persian, Roman, Byzantine, Danishment, Seljuk, Karaman and Ottoman Empires. The unconditional obedience of the people of Orthodox faith living in the region to the decisions to be issued from the Selime cathedral and monastery, and the key with the cross sign they made inside the church reveals the importance of this place in the past [26].

At the exit to Selime cathedral and monastery, we encounter a high corridor, which is part of the caravan route where camels were taken. Because of the market established in Selime, caravans were coming to Selime and camels were being taken up to the middle part of the cathedral for the safety of the caravans. Selime Cathedral and Monastery were built on top of this part for those who want to rest and worship. Structures carved into the rocks and mostly built as churches bear the traces of Byzantine art. It is also noteworthy that the upper part of the cathedral was built as a fortress. The walls and positions still exist today [26].

One of the most important features of Selime Kale Monastery is that it is the place where the clergy in the region were trained. Regional meetings and military base are located here. The first loud ritual was held in Selime Cathedral. Selime is the biggest monastery of Cappadocia. Kale Monastery Church is one of the largest religious organizations in Cappadocia. Monastery VIII. century. with XI. century, and the figured frescoes in the church are from the X. century. with the end of XI. YY. dated between their heads. There are depictions such as the ascension of Jesus, the Annunciation, and the Virgin Mary. The kitchen in the cathedral draws attention. In the kitchen, which was built in the form of a pyramid, oil lamps were built to illuminate the surroundings and there are other connected rooms next to it. Selime Monastery, on the other hand, was built as a two-storey courtyard. This is where loud liturgy, military and district meetings are held [26].

Selime Kadetra 513 pictures were taken with an 18.2 MP resolution camera at a 6.31 cm ground sampling interval. The eBee SenseFly UAV with real-time kinematic positioning was used in the study (Figure 2). A three-dimensional model was produced by evaluating the pictures in the PIX4D mapper program. In addition, dense point cloud, digital elevation model, orthophoto and three-dimensional model of the study area were produced. The products obtained are shown in Figures 3, 4, 5 and 6. Accuracy analyzes were made with half of the points measured on the obtained orthophoto and in the field.
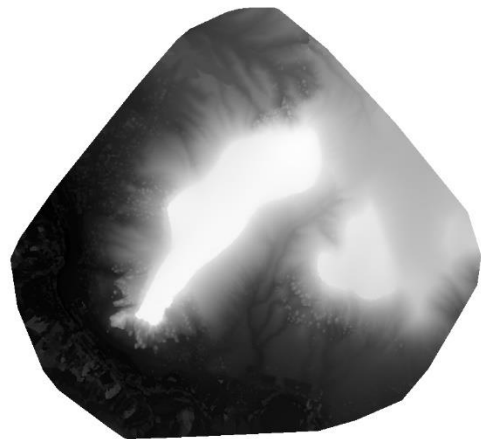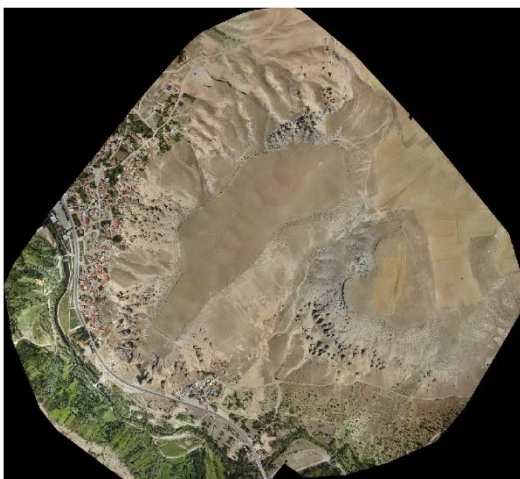
Figure 1. Selime Cadhetral
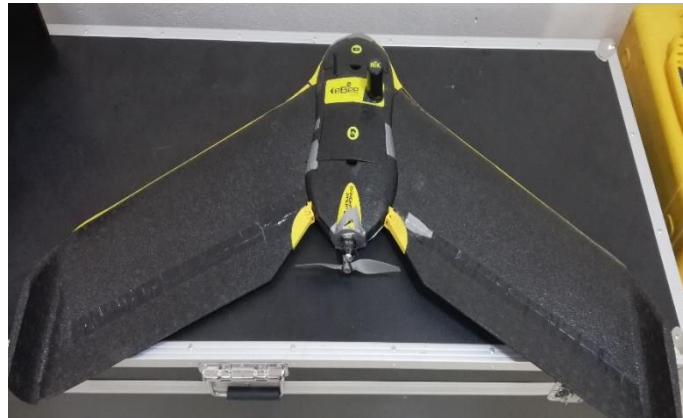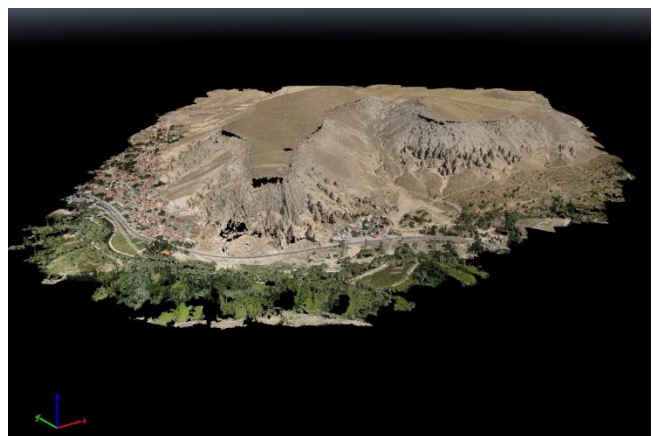

Figure 2. eBee SenseFly
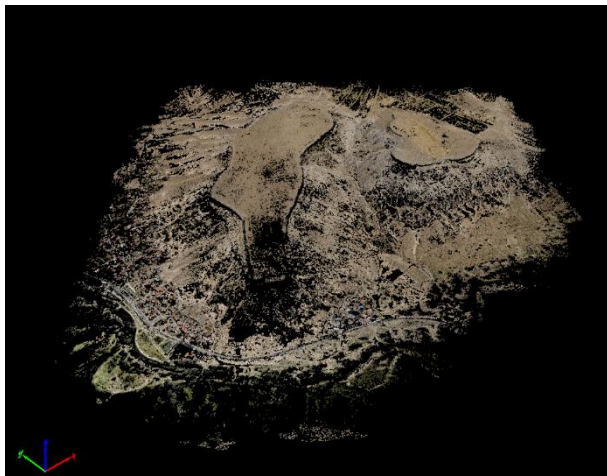
Figure 3. Dense Point Cloud

Figure 4. Digital Terrain Map

Figure 5. Orthophoto

Figure 6. 3D model

3. Results

As a result of the block balancing made in the PIX4D mapper program, the mean square error was obtained as 19.6 cm. Position errors at the control points were obtained as mx= 1.46 cm, my=1.46 cm and mz= 3.0 cm. Thanks to the developments in photogrammetric software and hardware in recent years, photogrammetric relief and 3D modeling studies can be done faster, more precisely and more economically. Historical and cultural heritages constitute important values of human history. With today's technologies, it is important to carry out studies that will be the basis for documenting, protecting and relaying these values, both in terms of protecting these values and helping humanity to recognize them in virtual environments.

4. Conclusion

One of the most important values between the past and the future of a society is historical and cultural heritage. It is important for humanity to protect them and keep them alive. For this reason, it is considered as one of the most important responsibilities of humanity to protect these heritages and determine their current status, document them, record them and restore them in accordance with their original form. In this study, three-dimensional modeling studies of unmanned aerial vehicles data of Selime Cadet, which is located in the borders of Aksaray province and which is the largest cathedral of Cappadocia, were carried out.

Author contributions

Adem Çolak: Conceptualization, Methodology, Software **Nusret Aktan:** Data curation, Writing-Original draft preparation, Software, Validation. **Hacı Murat Yılmaz:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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