6th Intercontinental Geoinformation Days

igd.mersin.edu.tr

Modeling of ancient period Sarcophagus with close-range photogrammetry

Ali Ulvi*[1], Abdurahman Yasin Yiğit [2], Murat Yakar [2]

[1]Mersin University, Department of Remote Sensing and Geographic Information Systems, Institute of Science, Mersin, Türkiye
[2] Mersin University, Engineering Faculty, Geomatics Engineering Department, Mersin, Türkiye

Keywords
Close Range Photogrammetry
3D Model
Sarcophagus

Abstract

Throughout history, Anatolia has been home to numerous societies with diverse customs. Every civilization has left behind too many cultural artifacts from its era to count after withdrawing from the historical arena. This heritage includes knowledge that dates back hundreds or even thousands of years. To be passed on to other generations, this heritage must be preserved. Technological ones have replaced traditional techniques of protection. Registering the work is the first step in the conservation and documentation process. The photogrammetric approach is one of the methods used today to recognize and capture the 3D model of the work without physically touching it. Actual texture can be applied to images using the photogrammetric approach, and a 3D model of the piece can be created. In this project, a 3D model of a Roman-era sarcophagus was created using photogrammetric methods. The Samsung M31 mobile phone camera was used to take pictures. By analyzing these data in Agisoft software, a 3D model of the sarcophagus was created with a dense point cloud with 0.3 mm spacing and an average position accuracy of 2.18 cm over the pairs of pictures. As a result of the study, using photogrammetric techniques in conservation and documentation studies to protect historical and cultural heritage and transfer it to the next generations has provided a significant advantage in terms of accuracy, speed, and cost.

1. Introduction

Türkiye is situated where three continents converge. As a result, the nation serves as a natural link between the three continents. Because of this benefit, it has become the intersection of significant roadways throughout history and into the present. This characteristic has led to significant civilizations in these countries (Yilmaz & Yakar, 2006a; 2006b; Alptekin & Yakar, 2020; 2021). We have acquired a variety of artifacts from several cultures that once flourished in Anatolia and left behind rich civilizational legacies (Alyilmaz et al., 2010; Yilmaz et al., 2007). The preservation of historical monuments or sites necessitates the creation of the initial technical papers of these works or fields and the coordinating of the relevant plans and research.

It will be feasible to quickly access all the information needed for any work that needs to be done on historical relics or locations using these documents. For work in the architectural fields, terrestrial photogrammetry offers several advantages that traditional approaches cannot swiftly and affordably supply (Yakar et al., 2014; Kanun et al., 2021a, b; Kuşak et al., 2021).

These benefits include:

-offering a high-quality graphical database;

-giving multidisciplinary research an essential tool and data sharing;

-making information easier to access and keep up with;

-Reduces costs because the information gathered throughout the preservation, restoration, and documentation process will be used in the future.

Documenting a historical relic has several advantages, such as:

-It has been noted that the work's physical description can be provided, the destruction's present state is disclosed, and it is possible to assess the building's current uses, Survey sample data will be gathered for architectural research; in rehabilitation efforts, a base is formed. It can be processed digitally for various purposes working in this industry. It serves as a model for scientists. With technology, new methods for

* **Corresponding Author**

*(aliulvi@mersin.edu.tr) ORCID ID 0000-0003-3005-8011
(ayasinyigit@mersin.edu.tr) ORCID ID 0000-0002-9407-8022
(myakar@mersin.edu.tr) ORCID ID 0000-0002-2664-6251

Cite this study

Ulvi, A., Yiğit, A. Y., & Yakar, M. (2023). Modeling of ancient period Sarcophagus with close-range photogrammetry. Intercontinental Geoinformation Days (IGD), 6, 317-320, Baku, Azerbaijan

accurately documenting cultural heritage have emerged due to research on the subject. For this reason, the first step before beginning the work to be done in line with the goal is the documentation of historical objects. In this regard, photogrammetric techniques have been employed in the literature to chronicle a variety of cultural heritages. According to Arca et al. (2011), surveys of several structures in the historic city of Safranbolu that were chosen based on their characteristics were prepared using terrestrial photogrammetry technology, and 3D models of these buildings were created. The pros and cons of several data-gathering techniques, including tachometer, photogrammetry, and terrestrial laser scanning, which are typically chosen in cultural heritage documentation projects, were covered by Grussenmeyer et al. (2008). The photogrammetry technique is suggested by Arias et al. (2005) as a preventive method that enables the detection, measurement, and monitoring of the temporal variation of some structural problems about a group of monuments belonging to the Spanish historical heritage, as well as the assessment of the level of material preservation.

Through the use of photogrammetry, volumetric data describing surface structures can be derived from parallax, or the variation in an object's apparent position as a result of the changing perspective offered by overlapping photos taken from various angles (Yakar, 2011; Karataş et al., 2022a). Structure-from-motion (SfM) photogrammetry implements and expedites the digital photogrammetric procedure using advancements in computer vision techniques. Because of this, SfM photogrammetry can employ unregistered image sets from consumer cameras that are not calibrated, but users must be aware of how camera settings might affect the quality of the data and products they produce (O'Connor et al., 2017). Prior to recently, institutions and organizations having access to expensive technology (such as laser scanners on piloted planes) frequently collected and provided topographic point cloud data to science consumers, and raw data required vital computers for data processing (Yakar & Doğan, 2018; Karataş et al., 2022b). Some users cannot access this data due to logistical requirements (Westoby et al., 2012). Contrarily, the development of SfM photogrammetry as a low-cost measurement instrument offered a more open method for scientists to gather and analyze their point cloud data (Karataş et al., 2022c). As a result, SfM photogrammetry is now recognized as a critical method of data gathering and analysis within the earth and environmental sciences. Scientists are now becoming data providers due to a shift in the geographical research paradigm (Garrett and Anderson, 2018); Consumer-grade cameras can be used to gather data, which can then be processed using SfM techniques to address various environmental science queries.

2. Material and Methods

In photogrammetry, the overlapping photos' camera locations and external orientation parameters are used to calculate the 3D coordinates of points on an object's surface. If there are at least three control points between the overlapping images, external orientation parameters can be determined. Internal orientation parameters must be known beforehand. However, the self-calibration technique does away with this requirement thanks to modern algorithms like Structure from Motion (SfM). The SfM algorithm-based photogrammetric software has made it incredibly simple to create 3D models from images taken with standard cameras and recreate surfaces (Ulvi et al., 2017; 2019). SfM is a photogrammetric approach or algorithm that automatically resolves the scene's geometry, camera positions, and orientation without the need to define a target mesh with predetermined 3D positions (Unal et al., 2014; Ünel et al., 2020). SfM is a measurement approach based on computer visualization techniques. It has grown in popularity because of the widespread usage of digital cameras, video cameras, and cell phones with cameras in this field (Uysal et al., 2013; Yakar et al., 2005; 2015). Due to its low cost, rapid results, and simple 3D measurement, its application in scientific studies has grown widely and has had a transformative impact on earth science research. The SfM technique builds 3D structures out of a series of overlapping photo frames. It functions by matching and identifying similarities among a collection of overlapping photographs. In this investigation, close-range photogrammetry techniques were used to record a sarcophagus of historical significance. A 32-megapixel smartphone camera captured 41 photographs (Table 1). When taking photos, the photogrammetric picture-shooting technique was considered (Figure 1). Agisoft Meteshape software created the monument's 3D model (Figure 2).

Table 1. Samsung M31 technique specification

Parameters	Value
Focal Lenght	35 mm
Aperture	F 2.0
Camera Resolution	32 MP

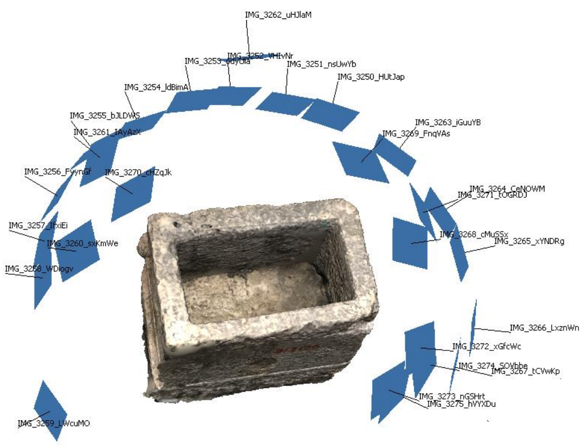

Figure 1. Photogrammetric picture-taking technique

The accuracy of the work on the 3D model has been checked. Control was made over the width and length of the sarcophagus. In reality, the width is 1,25 cm, and the height is 2,40 cm. In the control made on the model, the width is 1,25 cm, and the height is 2.38 cm. The difference of 2 cm height is the absence of sharp detail on the model to be measured. It is because the corner point is broken.

Figure 2. The 3D model obtained in Agisoft software

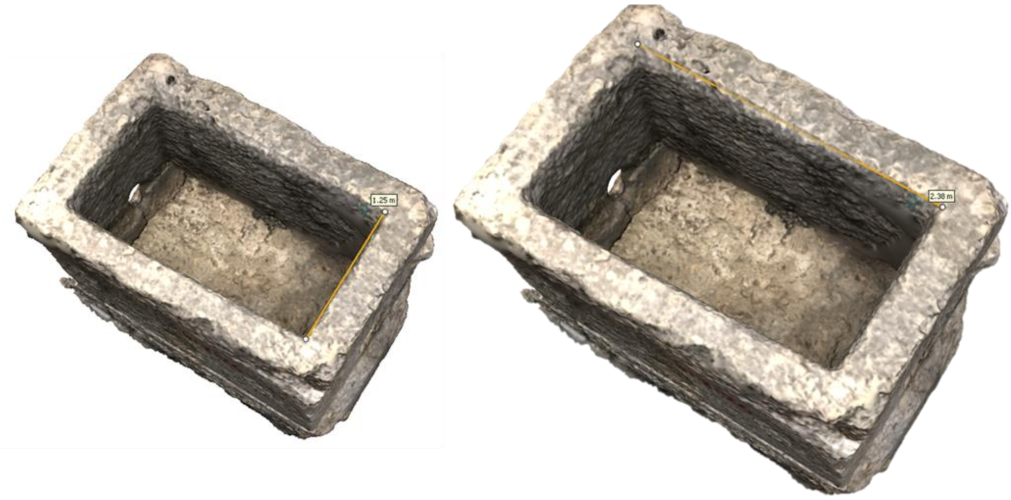

Figure 3. Controlling the dimensions of the 3D model

3. Conclusion

With the advancement of computer software and technology, it is now much simpler to make digital models of historical and cultural heritage buildings and use them to predict the behavior of complicated structures using 3D modeling. Since 3D models include a wealth of structural information, they are widely employed in documentation studies. The photogrammetry technique produces 3D models that are accurate in terms of appearance and size. Systems for photogrammetric measurement make it possible to model an item and determine its actual geometry. Additionally, because they are created from the actual image of the object, these technologies enable 3D models to contain accurate images.

References

Alptekin, A., & Yakar, M. (2020). Determination of pond volume using an uncrewed aerial vehicle. Mersin photogrammetry journal, 2(2), 59-63.

Alptekin, A., & Yakar, M. (2021). 3D model of Üçayak Ruins obtained from point clouds. Mersin Photogrammetry Journal, 3(2), 37-40.

Alyılmaz, C., Alyılmaz., S., & Yakar, M. (2010). Measurement of petroglyhps (rock of arts) of Qobustan with close range photogrammetry. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 38(Part 5), 29-32.

Arca, D., Bayık, Ç., Acar, H., Alkan, M., ve Şeker, D.Z. (2011). Safranbolu Tarihi Kenti Örneğinde Dökümantasyon Çalışmalarında Fotogrametri Ve Cbs'nin Birlikte Kullanımı. TMMOB Harita ve Kadastro Mühendisleri Odası 13. Türkiye Harita Bilimsel ve Teknik Kurultayı 18-22 Nisan, Ankara.

Arias, P., Herráez, J., Lorenzo, H., ve Ordóñez, C. (2005). Control of Structural Problems in Cultural Heritage Monuments Using CloseRange Photogrammetry and Computer Methods Control of Structural Problems in Cultural Heritage Monuments Using Close-Range Photogrammetry and Computer Methods. Computers and Structures, 83(21–22), 1754-1766

Garrett B and Anderson K (2018) Drone methodologies: Taking flight in human and physical geography. Transactions of the Institute of British Geographers 43, 341–359

Grussenmeyer, P., Landes, T., Voegtle, T., ve Ringle, K. (2008). Comparison Methods of Terrestrial Laser

Scanning, Photogrammetry and Tacheometry Data for Recordıng of Cultural Heritage Buildings. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B5. Beijing.

Kanun, E., Alptekin, A., & Yakar, M. (2021a). Cultural heritage modelling using UAV photogrammetric methods: a case study of Kanlıdivane archeological site. Advanced UAV, 1(1), 24-33.

Kanun, E., Metin, A., & Yakar, M. (2021b). Yersel Lazer Tarama Tekniği Kullanarak Ağzıkara Han'ın 3 Boyutlu Nokta Bulutunun Elde Edilmesi. Türkiye Lidar Dergisi, 3(2), 58-64.

Karataş, L., Alptekin, A., & Yakar, M. (2022a). Creating Architectural Surveys of Traditional Buildings with the Help of Terrestrial Laser Scanning Method (TLS) and Orthophotos: Historical Diyarbakır Sur Mansion. Advanced LiDAR, 2(2), 54-63.

Karataş, L., Alptekin, A., Kanun, E., & Yakar, M. (2022b). Tarihi kârgir yapılarda taş malzeme bozulmalarının İHA fotogrametrisi kullanarak tespiti ve belgelenmesi: Mersin Kanlıdivane ören yeri vaka çalışması. İçel Dergisi, 2(2), 41-49.

Karataş, L., Alptekin, A., Karabacak, A., & Yakar, M. (2022c). Detection and documentation of stone material deterioration in historical masonry buildings using UAV photogrammetry: A case study of Mersin Sarisih Inn. Mersin Photogrammetry Journal, 4(2), 53-61.

Korumaz, A. G., Dülgerler, O. N., & Yakar, M. (2011). Kültürel mirasin belgelenmesinde dijital yaklaşimlar. Selçuk Üniversitesi Mühendislik, Bilim ve Teknoloji Dergisi, 26(3), 67-83.

Kusak, L., Unel, F. B., Alptekin, A., Celik, M. O., & Yakar, M. (2021). Apriori association rule and K-means clustering algorithms for interpretation of pre-event landslide areas and landslide inventory mapping. Open Geosciences, 13(1), 1226-1244.

O'Connor J, Smith MJ and James MR (2017) Cameras and settings for aerial surveys in the geosciences: Optimising image data. Progress in Physical Geography: Earth and Environment, 41, 325–344.

Ulvi, A., Yakar, M., Alyilmaz, C., & Alyilmaz, S. (2017). Using the close range photogrammetry technique in 3-dimensional work: History of obrukhan sample. International Multidisciplinary Scientific GeoConference: SGEM, 17, 347-355.

Ulvi, A., Yiğit, A. Y. & Yakar, M. (2019). Modeling of Historical Fountains by Using Close-Range Photogrammetric Techniques. Mersin Photogrammetry Journal, 1(1), 1-6.

Unal, M., Yakar, M., & Yildiz, F. (2004, July). Discontinuity surface roughness measurement techniques and the evaluation of digital photogrammetric method. In Proceedings of the 20th international congress for photogrammetry and remote sensing, ISPRS (Vol. 1103, p. 1108).

Ünel, F. B., Kuşak, L., Çelik, M., Alptekin, A., & Yakar, M. (2020). Kıyı çizgisinin belirlenerek mülkiyet durumunun incelenmesi. Türkiye Arazi Yönetimi Dergisi, 2(1), 33-40.

Uysal, M., Polat, N., Toprak, A. S., & Yakar, M. (2013). 3D modeling of historical doger caravansaries by digital photogrammetry.

Westoby MJ, Brasington J, Glasser NF, et al. (2012) 'Structure-from-Motion' photogrammetry: A low-cost, effective tool for geoscience applications. Geomorphology 179: 300–314.

Yakar, M. & Dogan, Y. (2018). 3D Reconstruction of Residential Areas with SfM Photogrammetry. In Conference of the Arabian Journal of Geosciences, 73-75.

Yakar, M. (2011). Using close range photogrammetry to measure the position of inaccessible geological features. Experimental Techniques, 35, 54-59.

Yakar, M., & Doğan, Y. (2017). Mersin Silifke Mezgit Kale Anıt Mezarı fotogrametrik rölöve alımı ve üç boyutlu modelleme çalışması. Geomatik, 2(1), 11-17.

Yakar, M., & Doğan, Y. (2017). Uzuncaburç Antik Kentinin İHA Kullanılarak Eğik Fotogrametri Yöntemiyle Üç Boyutlu Modellenmesi. 16. Türkiye Harita Bilimsel ve Teknik Kurultayı. TMMOB Harita ve Kadastro Mühendisleri Odası, Ankara.

Yakar, M., & Kocaman, E. (2018). Kayseri-Sahabiye Medresesi 3-boyutlu modelleme çalışması ve animasyonu. International Journal of Engineering Research and Development, 10(1), 133-138

Yakar, M., Karabörk, H., Yılmaz, H.,M. (2000). Yersel Fotogrametrinin Kullanım Alanları. Niğde Üniversitesi Mühendislik Bilimleri Dergisi, 4, (1), 18-28.

Yakar, M., Orhan, O., Ulvi, A., Yiğit, A. Y., & Yüzer, M. M. (2015). Sahip Ata Külliyesi Rölöve Örneği. TMMOB Harita ve Kadastro Mühendisleri Odası, 10.

Yakar, M., Toprak, A. S., Ulvi, A., & Uysal, M. (2015). Konya Beyşehir Bezariye Haninin (Bedesten) İHA ile fotogrametrik teknik kullanilarak üç boyutlu modellenmesi. Türkiye Harita Bilimsel ve Teknik Kurultayı, 25, 28.

Yakar, M., Yıldız, F., & Yılmaz, H. M. (2005). Tarihi ve Kültürel Miraslarin Belgelenmesinde Jeodezi Fotogrametri Mühendislerinin Rolü. TMMOB Harita ve Kadastro Mühendisleri Odası, 10.

Yakar, M., Yılmaz, H. M., & Mutluoglu, O. (2014). Performance of photogrammetric and terrestrial laser scanning methods in volume computing of excavation and filling areas. Arabian Journal for Science and Engineering, 39, 387-394. https://doi.org/10.1007/s13369-013-0853-1

Yilmaz, H. M., & Yakar, M. (2006a). Lidar (Light Detection and Ranging) Tarama Sistemi. Yapı Teknolojileri Elektronik Dergisi, 2(2), 23-33.

Yilmaz, H. M., & Yakar, M. (2006b). Yersel lazer tarama Teknolojisi. Yapı teknolojileri Elektronik dergisi, 2(2), 43-48.

Yilmaz, H. M., Yakar, M., Gulec, S. A., & Dulgerler, O. N. (2007). Importance of digital close-range photogrammetry in documentation of cultural heritage. Journal of Cultural Heritage, 8(4), 428-433.