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Documenting historical buildings using high-resolution photographs obtained with smartphones: The Case of Latifiye (Abdullatif) Mosque, Mardin/Türkiye

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Abstract

In today's context, the use of technology has become increasingly widespread in the process of gathering, processing, documenting, and presenting data obtained through photogrammetry. Advancements in technology have made it easier to digitally document historical artifacts using photogrammetric methods. Traditional measurement techniques, laser scanning, and photogrammetry, or combinations of these methods, are commonly used in the documentation of historical artifacts. In this study, the focus was on the application of close-range photogrammetry, a subfield of photogrammetry, using the non-metric cameras of smartphones that we frequently use in our daily lives. The three-dimensional images of Mardin Latifiye Mosque were obtained using photographs captured with smartphones. Additionally, a panoramic view of the mosque was created, allowing for the examination of materials and material deterioration. Archaeological data was added to the obtained images, and all the work conducted in the area was made accessible through a web platform. This article provides a detailed explanation of the methods followed at every stage to generate three-dimensional models from smartphones. It also describes the necessary processes to create 360-degree panoramic images.

1. Introduction

Although laser scanning provides a faster technique for obtaining point cloud data, photogrammetric methods have gained prominence due to their economic nature, accessibility, portability, and the fact that they do not require specialized expertise (Kanun et al., 2022). Photogrammetry, particularly the production of three-dimensional (3D) models from two-dimensional (2D) photographs taken with non-metric cameras, stands out as the most widely used technique (Karataş & Menteşe, 2022).

Architectural and structural features, geometric shapes, and accurate information about materials are crucial foundations for the restoration of historical artifacts (Karataş & Dal, 2023). Therefore, documenting historical artifacts and monitoring their deformations are of vital importance (Karataş et al., 2022a). Measuring a structure using traditional methods can be costly and time-consuming, particularly when accessing and measuring the higher parts of the structure is challenging. Remote sensing and photogrammetric methods can be employed for this purpose (Karataş et al., 2022b). The integration of non-metric cameras into smartphones has made it possible to utilize photographic data obtained from them for photogrammetric evaluations (Karataş et al., 2022c). With the advent of smartphones in this field, access to data collection tools has reached a high level. As data collection materials have advanced, many individuals have started using the photogrammetry technique with photographic data obtained from smartphones (Karataş et al., 2022d).

In parallel with advancing technology, photogrammetry now utilizes images produced with cameras or videos, as well as electronically recorded images with scanners, instead of relying solely on traditional photographs. There are a limited number of studies in the literature that aim to investigate the overall

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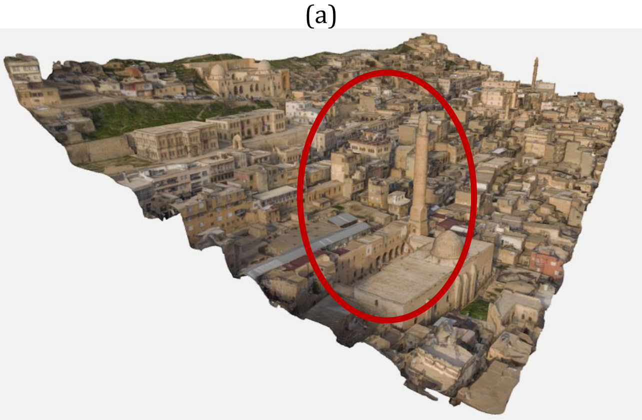
photogrammetric accuracy of smartphones. The results of these studies demonstrate that smartphones can be used in digital photogrammetry (Wrózynski et al., 2017; Dabove et al., 2019; Yilmazturk & Gurbak, 2019).

The presented paper describes the generation of three-dimensional images of Mardin Latifiye Mosque using photographs captured with smartphones. Additionally, a panoramic view of the mosque was created, allowing for the examination of materials and material deterioration. Archaeological data was integrated into the obtained images, and all the work conducted in the field was made accessible through a web platform. The article provides explanations of the methods followed at every stage for generating three-dimensional models from smartphones and describes the necessary procedures for producing 360-degree panoramic images.

1.1. The location, history, and significance of the structure.

The mosque, known as Latifiye Mosque in the local community, bears the characteristics of Artukid mosque architecture. It is located south of Cumhuriyet Square, which is rich in historical fabric. It is situated in the urban conservation area of Artuklu District in Mardin Province, specifically on the southern side of the 1st Avenue in Latifiye Neighborhood, registered under parcel number 14 in Plot 309. The property is owned by the Regional Directorate of Foundations (Figure 1).

(a)



(b)

Figure 1. a) Site plan: The location of Latifiye Mosque within the topography of Mardin city is shown. b) Section: The section of Latifiye Mosque depicting its vertical representation within the city's topography.

According to the inscription on the portal, the construction of the building was commissioned by Abdullatif, who served two Artuklu sultans, in 1371 (Abdulgani Efendi, 1999; Alioğlu, 2000; Altun, 2011; Ahunbay, 2005; Gabriel, 1940) (Figure 2).

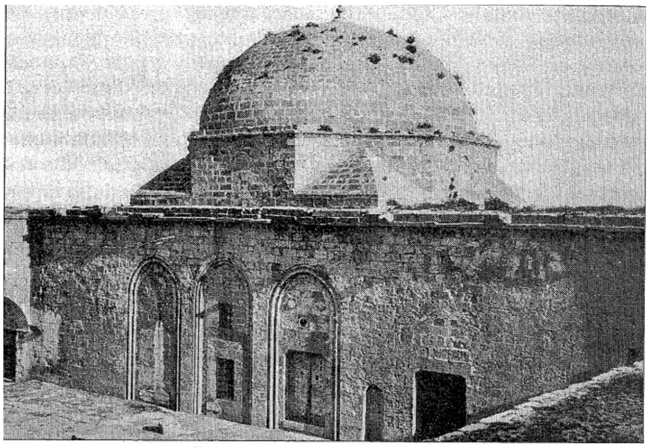


Figure 2. Latifiye Mosque (Gabriel, 1940)

The mosque is currently open for religious worship. On the east and north sides of the building, there are houses adjacent to the southern and western garden walls. Recently, the monumental features of the structure, such as the low-arched entrance door from the street to the outer courtyard and the entrance to the inner courtyard, have been modified. It is open for worship and visitation. Repair and renovation works have been carried out on the building until the present day (Mardin Governorship Provincial Directorate of Culture and Tourism, 2013).

2. Method

The study was conducted in two stages: fieldwork and office work. In the first stage, the building was examined on-site, and photographs of the structure were taken.

In the first stage of the study, the images of the historical structure obtained through fieldwork were transferred to the open-source 3DF Zephyr software for digital evaluation. 3DF Zephyr is a photogrammetry software used to create 3D models from photographs. This program utilizes photogrammetry techniques to identify 3D points in the photos and generate a point cloud (source: https://www.3dflow.net/3df-zephyr-photogrammetry-software/). In this case, 85 photos taken with the non-metric camera on the smartphone were used in 3DF Zephyr. The collected photo data was first introduced to the software. After the import process, the production of a 3D point cloud was initiated. The photos captured in the field were transformed into a point cloud using the open-source 3DF Zephyr software. Finally, material texture data was added to the completed 3D point cloud, and the documentation of the historical structure was completed.

The workflow of the study is presented below:

Step 1: Fieldwork - Obtaining photographs of the structure.

Step 2: Importing Photos - The photos are imported into the 3DF Zephyr software and used to create a 3D point cloud and model.

Step 3: Point Cloud Generation - The imported photos will appear in the "Photos" section of your project. Click on a button like "Generate Point Cloud" to initiate the process. Once completed, the point cloud will be displayed in the "Point Cloud" section of your project.

Step 4: Processing and Editing the Point Cloud - 3DF Zephyr provides various tools and options to process and edit the generated point cloud. You can make corrections, remove unnecessary points, adjust colors, apply filters, and perform other editing tasks.

Step 5: Orthophoto and 3D Model Generation - An orthophoto (or orthomosaic) is a geometrically corrected image with a uniform scale. Unlike standard images with a specific perspective, an orthophoto has the same distortion as a map and allows for accurate measurement of distances. The software can be used to generate orthophotos and 3D models based on the processed point cloud.

Within the 3DF Zephyr software, there are different options for creating orthophotos available in the "Workflow" menu. In the previous step of the study, the dense point cloud obtained can be used to create an orthophoto using the "Orthophoto from Dense Point Cloud (requires dense point cloud)" option. Additionally, the software offers the options of "Orthophoto from Sparse Points (does not require dense point cloud)" and "Orthophoto from Mesh (requires mesh)".

After generating the orthophoto automatically from the dense point cloud, it is necessary to export the orthophoto. The software allows you to select export settings and additional deliverables for the orthophoto.

The orthophoto can be exported in image formats such as *.jpg, *.png, and *.tif.

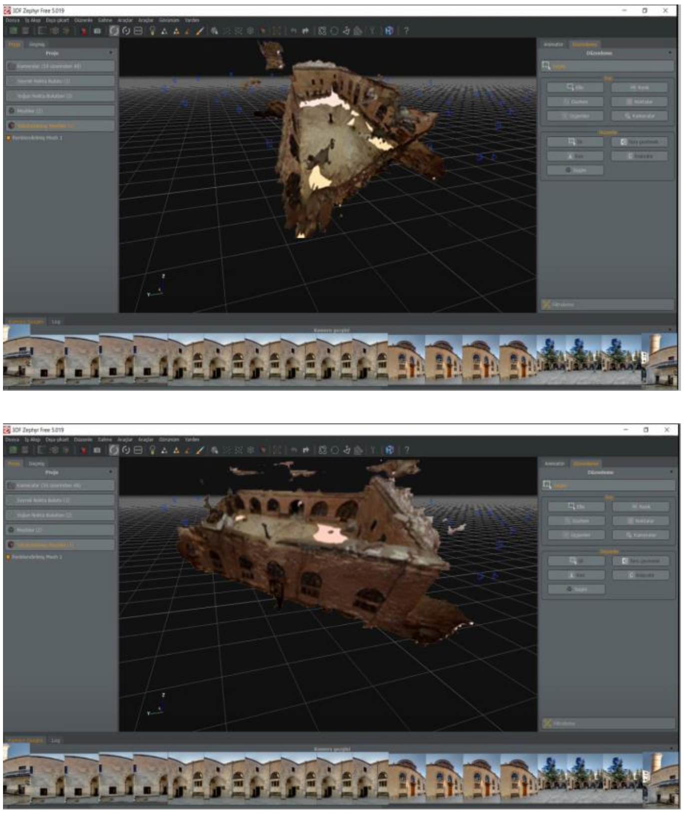


Figure 3. Some examples of dense point cloud visuals obtained using the field-acquired photo data of the Latifiye Mosque in 3DF Zephyr software

3.Results

In the study, elevation drawings were created using the orthophotos obtained from the point clouds in AutoCAD 2020 software. By utilizing these drawings, the facade architecture of the mosque was explained and documented in written form. Below are the descriptions and elevation drawings related to the facade architecture of the structure.

The structure has a facade facing the front courtyard and four facades opening to the main courtyard. The north facade is referred to as facade number 1, the south facade as facade number 2, and the east facade facing the front courtyard as facade number 3. The east facade facing the main courtyard is labeled as facade number 4. The west facade of the structure is facade number 5 (Figure 4).

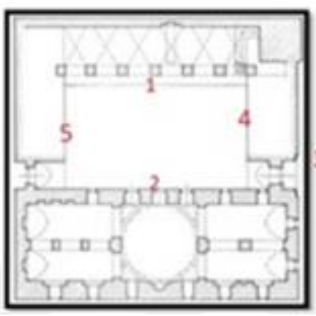


Figure 4. According to the plan drawing of Latifiye Mosque, the numbering of the facades is as follows (Karataş, 2017)

The facade numbered as 1 consists of a pointed arch arcade structure supported by thick piers, extending in the east-west direction along the northern side of the courtyard. It opens to the south with a cross-vaulted portico structure, which is the third one from the east and includes a selsebil (a public water fountain). This facade is evaluated together with the courtyard facade like the other facades. Due to later interventions, the original texture of the arcade has been compromised, and the arcade arches have been closed to create enclosed spaces. These spaces are currently used as a tea house and storage (Figure 5).

The facade numbered as 2 is located on the south side of the inner courtyard and consists of the rectangular-plan prayer hall extending in the east-west direction. It is covered with a series of five barrel vaults running parallel to the qibla wall (the wall facing Mecca). The vaults are supported by two pointed arches at the east and west, and by the southern and northern walls, dividing the space into two domed sections. The transition elements of the wide dome in front of the mihrab (prayer niche) are achieved with two-tiered muqarnas-adorned squinches. The dome, resting on an octagonal drum, provides illumination to the exterior through four windows, and its upper part displays fine stone masonry. This plan scheme represents a characteristic design of an Artukid-period mosque with a rectangular layout and a domed section in front of the mihrab, which is also found in similar examples in Mardin and its surrounding areas (Figure 6).

The facade numbered as 3 is the entrance facade of the building facing the street (Figure 7).

The facade numbered as 4 is the eastern wing of the courtyard, constructed in two stories with finely cut limestone. This wing extends in the north-south direction and comprises the ground floor, which consists of three rooms serving as part of the mosque's madrasa section, and the upper floor, which can be accessed through a staircase opening that has been closed off in later periods. On the southern side of this wing, there is a pointed-arched iwan that provides access to the main entrance of the mosque's inner courtyard. On the north side of the iwan, there is a small room with a door, while on the south side, there is a lintelled doorway leading to the prayer hall. The second floor consists of two spaces (Figure 8).

The facade numbered as 5 is the western facade of the courtyard, constructed in two stories with smooth limestone. However, similar to the eastern facade, this facade has undergone numerous alterations over time. Only one floor of this two-story facade remains standing, and the traces of the second floor can still be observed. Currently, this facade features a semi-circular arched structure supported by piers and an entrance with a depressed arch opening, located on the southern side and adjacent to the prayer hall wall, providing access to the rear courtyard (Figure 9).

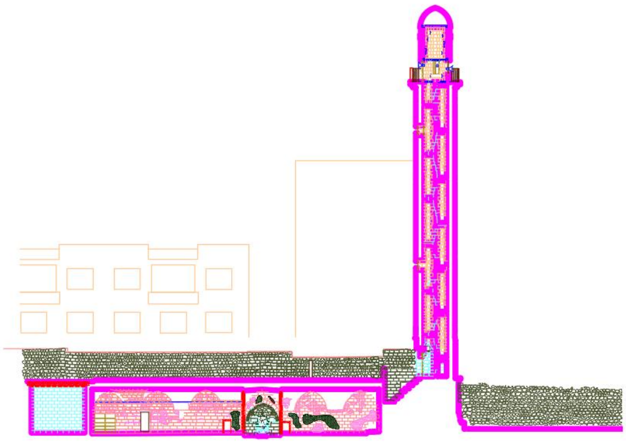


Figure 5. Analytical elevation drawing of Latifiye Mosque facade number 1

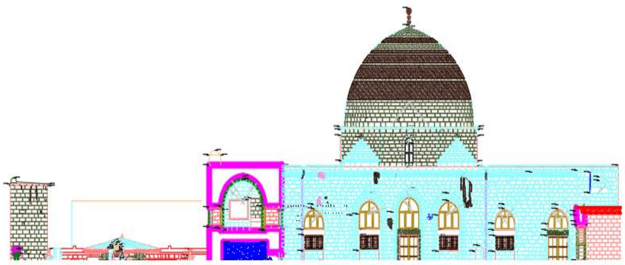


Figure 6. Analytical elevation drawing of Latifiye Mosque facade number 2

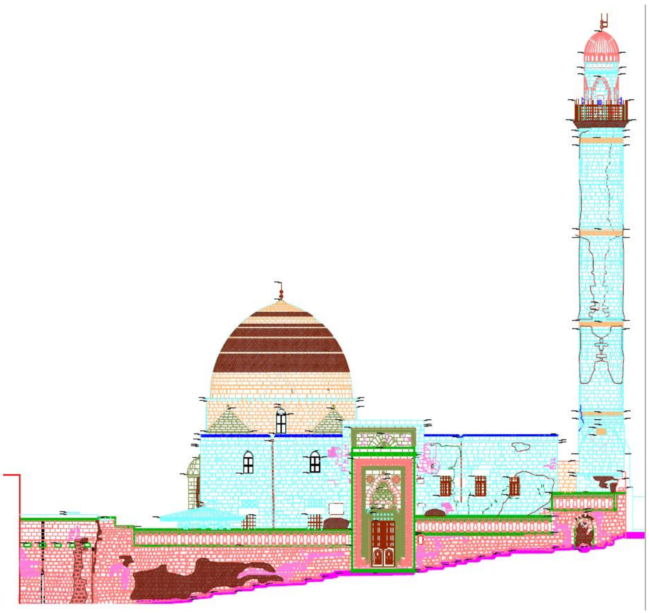


Figure 7. Analytical elevation drawing of Latifiye Mosque facade number 3

3. Discussion and Conclusion

Using photogrammetric methods for documenting historical artifacts is advantageous compared to traditional methods that require time-consuming and laborious measurements. However, photogrammetric methods have disadvantages such as expensive measurement tools, high-dimensional data, and complex modeling processes. In this study, the performance of photogrammetric methods in documenting historical artifacts was examined by utilizing non-metric cameras like smartphones, which are commonly used in our daily lives and more easily accessible compared to alternatives. The case study for this research was conducted on Latifiye Mosque, located in the city of Mardin, which holds historical significance.

The results of the study show that the proposed method can be used as a foundation for documenting and preserving cultural heritage. It has been demonstrated that high-resolution photographs taken with smartphones can be used to generate dense point clouds using various software, which in turn can provide scaled orthophotos to assist in the creation of architectural drawings. This method can be utilized in restoration projects to identify deformations occurring on historical artifacts and monitor changes that take place over time. Additionally, due to the wide user base and user-friendly nature of mobile phones, it is believed that they can contribute to the documentation of numerous cultural heritage sites.

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