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Three-dimensional modeling of the Kubbe-i Hasiye Shrine with terrestrial photogrammetric method

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Abstract

Natural and unnatural structures, which are the subject of our cultural heritage, are in constant danger of extinction as a result of both man-made destruction and natural events such as natural disasters, rains and strong winds. Therefore, it is necessary to take very good protection measures in order to keep cultural assets alive and transfer them to future generations. In the light of today's technology, different techniques have been developed to take these protection measures. One of these techniques is terrestrial photogrammetry technique. With this technique, all the details of the building are measured and a three-dimensional visual model of the building can be created thanks to the pictures of the building. Thus, by recording all the features of the building such as detail dimensions, shape, size, type of building material, necessary interventions can be made in case of any structural deterioration, modification and repair that may occur in the building. In this study, it is aimed to measure the Kubbe-i Hasiye tomb located in the center of Tillo district of Siirt province, photogrammetrically, and to make a three-dimensional modeling with the pictures taken of the tomb by making three-dimensional modeling. As a result of the measurements made on the model obtained as a result of the study, precision was obtained in the reference intervals determined and the amount of error was determined below 2 cm.

1. Introduction

Cultural and natural structures in any geography are like mirrors that reflect all the values they have such as the historical past, lifestyles, religious beliefs, national traditions and customs of the civilizations that have lived and are living in that geography. However, they witnessed all the events experienced by the civilizations that lived in that region (Uysal et al. 2013). Cultural and natural structures have always faced the danger of being damaged and destroyed due to natural and unnatural causes from past to present. As a matter of fact, it is seen that many buildings with a recent past have not survived and disappeared due to these reasons. The main reasons for this are the failure to take adequate measures to protect these structures and the failure to use scientific and technical methods to keep these cultural heritages alive. The first way to protect our historical artifacts that are the subject of cultural heritage is to document these works digitally as soon as possible (Kaya et al. 2021). In addition, the most important feature of the documentation to be made in order to transfer these works to future generations should be a sensitive documentation work (Yakar et al. 2009).

These structures of the world heritage have been exposed to both natural and unnatural human-induced effects. There are many different scientific methods for the preservation and survival of these structures. Photogrammetry, which is one of these methods, is a scientific method that allows these natural and unnatural structures to be modeled in three dimensions together with the pictures taken by allowing the measurement of all detail points (Yakar and Mohammed 2016). Thanks to the photogrammetry technique, digital documentation of

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cultural assets can be realized very quickly and reliably (Yakar and Yılmaz 2008).

In case of damage to historically important buildings, whose three-dimensional modeling is done with the photogrammetry method, repairs and restoration works can be carried out correctly and in accordance with the historical texture of the building, and at the same time, three-dimensional models of these structures can be produced when desired. Along with the developing technology, photogrammetric methods have also developed and started to use remotely controlled aerial vehicles such as laser measuring devices and Unmanned Aerial Vehicles that produce thousands of detail point information per second. This situation has led to the use of photogrammetry in many space (Yakar et al. 2005).

Terrestrial photogrammetry technique allows three-dimensional modeling of objects. In this technique, with the help of geodetic measurements and photographs of the objects to be modeled, a three-dimensional model is obtained by making drawings on special technical software in the digital environment. Three-dimensional position information of the object is obtained through this model (Şanlıoğlu et al. 2013). In terrestrial photogrammetry technique, photographs are made with cameras that provide images as single or double images. Usually, images are provided as double images from distances up to 25 m (Yılmaz et al. 2000).

In terrestrial photogrammetry, the reception center is above ground. Rays reflected from the object can be recorded both analog and digital. Thanks to the technological developments, terrestrial photogrammetry technique has started to be used in many fields, especially in industry. This technique is used in fields such as engineering applications, architecture, medicine, geological activities, as well as in studies such as the protection, restoration and digital recording of cultural assets (Yılmaz et al. 2000).

Terrestrial photogrammetry technique has been used for many years for archaeological measurements and documentation of cultural artifacts. With the technological developments in photogrammetry, this method has become a much more economical and useful method for the preservation and digital recording of cultural assets (Suveg and Vosselman 2000). With this technique, the real dimensions of the work being modeled can be determined geometrically and the geographical location of the work can be determined with the obtained three-dimensional model (Mırdan and Yakar 2017). In this photogrammetry technique, while modeling with traditional methods, objects such as ornaments, relief gilding, etc., cannot be adequately modeled. In this case, these problems can be solved by modern methods of terrestrial photogrammetry such as laser scanning or close-up photogrammetry (Ulvi et al. 2019).

2. Material and method

2.1. Kubbe-i Hasiye Shrine

The shrine is located on a dominant hill in the Fakirullah neighborhood of Tillo district, which is 9 km away from the city center of Siirt (Figure 1). The shrine is geographically located at latitude 37.9410041 and longitude 42.006942. Known to have been built in the last quarter of the 18th century for Zemzem-il Hassa (Hasiye), one of the female awliya descendants of His Holiness İsmail Fakirullah who lived in Tillo District, known as the land of saints, the shrine, which is known to have been built in the last quarter of the 18th century, has undergone restoration work over the years and has taken its present form. The shrine has dimensions of 10 x 12 m and a height of 4 m (Figure 2). It has a fine workmanship and a simple architecture. Just below the roof eaves, there are four small windows with patterns and embossments that allow light to enter, together with the extremely gentle and embossed patterns on all four sides of the building. At the same time, there is a small entrance gate 1.1 m long and 50 cm wide for those who enter by bowing respectfully. The Dome of the Annunciation shrine is in a structure where there is a constant density, which is visited by people not only for faith-based but also for recreational purposes, as it has a large garden and trees around the garden.

Figure 1. Study Area (URL1)

Figure 2. Kubbe-i Hasiye Shrine

2.2. Field Study

Spectra Cors GPS (Figure 3) and Gowin TKS-202 total station (Figure 4) measurement devices were used for field measurement, Nikon D5100 camera was used for taking photographs.

Before starting the measurement process in the field, the project area was visited and the points where the polygons to be established were determined and land reconnaissance was made. In addition, the photographs of the building were taken and a sketch was created by marking the measured points on the structure by taking the printout. Fixed points of the polygons were determined and benchmark sketches were arranged. A closed polygon network was formed by establishing five polygon points around the building in a way that they would see each other, and coordinated in the national system with the Cors GPS device (Figure 5 and 6). A total station device was installed on the measured polygon points and zero connection was made from the polygon to the polygon, and the error value was determined to be below 0.5 cm and the measurement was continued with the total station. Polygon points coordinated with Cors GPS measuring device were used as control points. In this way, three-dimensional coordinates of the structure were obtained by making measurements on the structure with the help of these points with the total station measuring device. Polygons P.2 and P.3 had to be installed closer to the structure, since there was a wooded part in the west and northwest of the building, causing problems during photographing and measurement.

The measurement process of the study took about half a day. The measurement process was completed by measuring the points marked on the sketch of the work. In addition, pictures were taken of the same surface of the building from three different angles in order to make balancing easily. The zoom setting of the camera is fixed during photo shooting. Attention was paid to take the photographs at an angle and to cover each other so that the overlapping can be done easily. In order for the shooting points of the photos not to be the same, the photo shooting process was carried out by relocating them.

2.3. Office Work

The measurement values obtained from the field were transferred to the computer environment and obtained in .ncn file format in Netcad 5.1 software and then converted into .txt format for evaluation in Photomodeler software. The parameters of the camera from which the photographs were taken were introduced in the Photomodeler (PM) software and the calibration process was carried out before proceeding to the drawing process. For the calibration process, the calibration paper was printed in A4 size from the output part of the PM software. In order for the calibration process to be performed correctly, 8-12 photos of the calibration paper should be taken. The printout was placed on a flat surface, and 10 photographs were taken by turning it clockwise. Care was taken to ensure that the camera was in a horizontal and vertical position during photographing. After the successful completion of the calibration process, the balancing process was also done successfully and the drawing process was started.

Figure 3. Cors GPS GNSS receiver (URL 2)

Figure 4. Total station (URL 3)

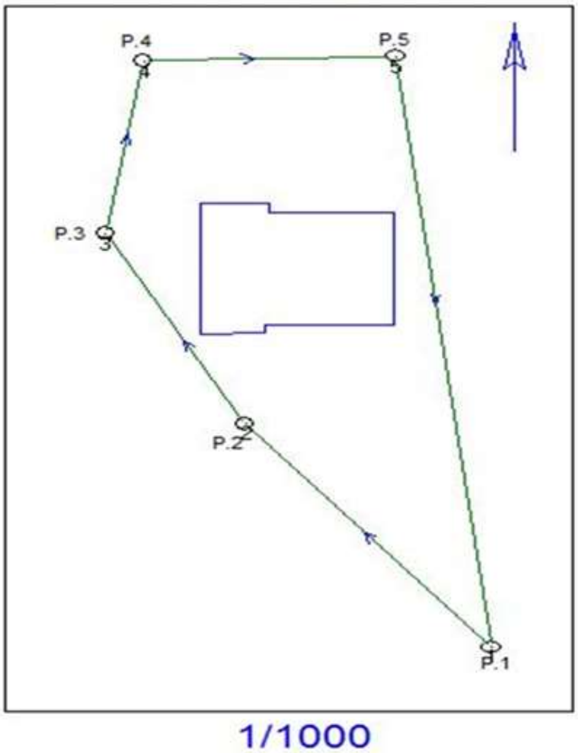

Figure 5. Polygon mesh

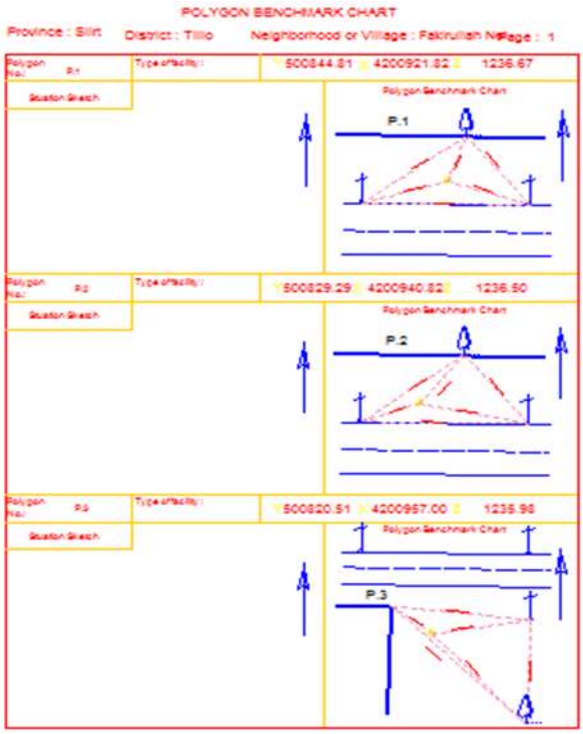

Figure 6. Polygon benchmark chart

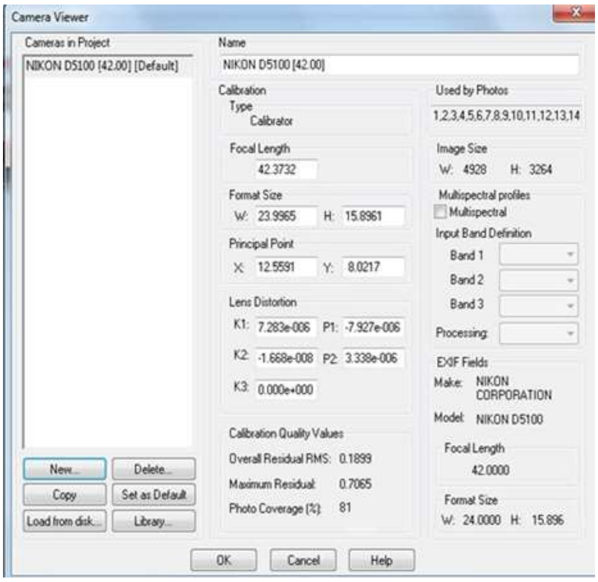

Figure 7. Calibration parameters

Figure 8. Camera (URL 4)

Table 1. D5100 Camera features (URL 5)

Sensor type	CMOS
Efficient pixel	16 MP
Focal length	18-55 mm
Screen width	3.0 inç
Weight	560 gr
Battery capacity	1030 mAh

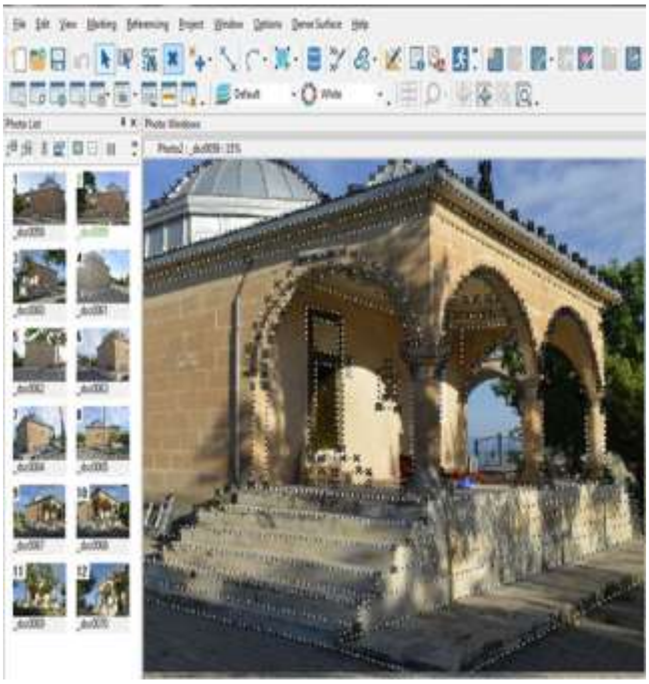

Figure 9. PM detail drawing

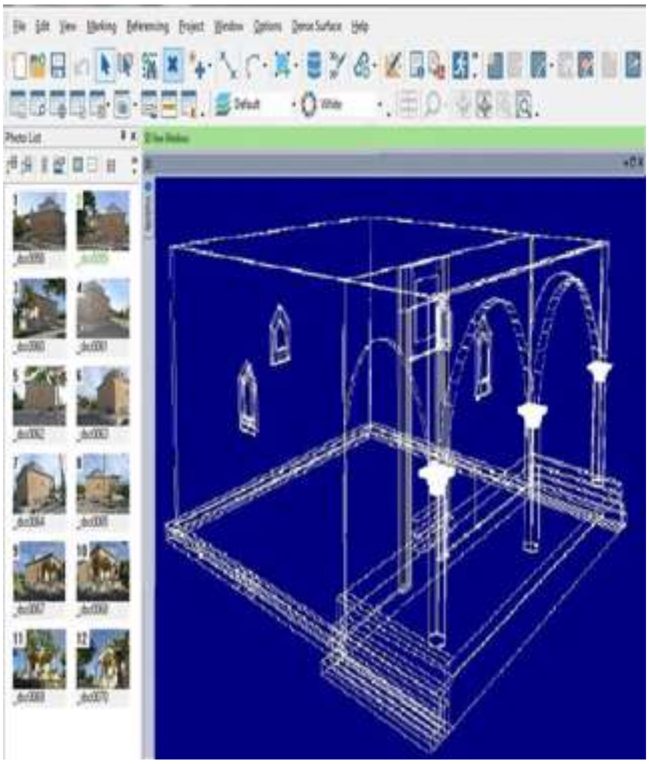

Figure 10. 3D drawing stage of the building

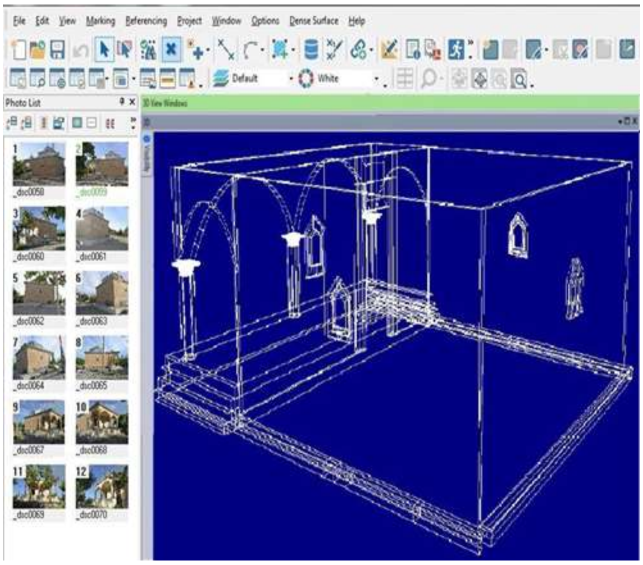

Figure 11. 3D drawing screenshot of structure

Figure 12. Textured of building

Figure 13. 3D view of the model

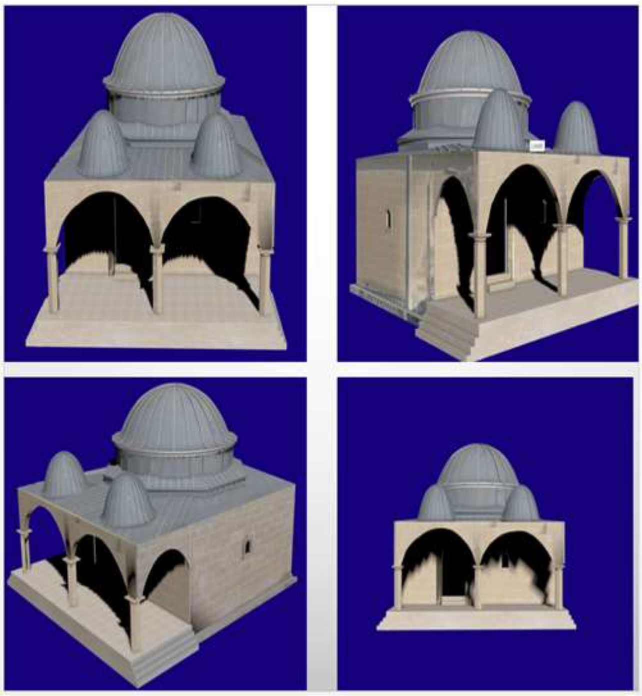

Figure 14. Screenshot of the model taken from different angles

Conclusion

Today, because historical buildings shed light on the past and are a bridge between the past and the future, the preservation and restoration methods of these works are of great importance as well as the preservation and restoration of historical buildings and artifacts. It provides an innovative participation in this field as a method with lower cost, less time and high sensitivity, with photogrammetric studies carried out by the discipline of surveying engineering, to the studies carried out by architects with survey studies and classical methods until now. One of the most important advantages of the photogrammetric method is that it enables historical buildings and artifacts to be recorded digitally and digitally in three dimensions. Since the method is based on sensitive measurements, extremely sensitive measurements can be made on the works, so in case of any restoration work or repair, the original dimensions of the work are taken into account. Miniatures of the works recorded in this way photogrammetrically can be produced using their numerical measurements or they can be opened to visit as an online museum in the digital environment.

Author contributions

Fatih Pulat Conceptualization, Methodology, Software **Murat Yakar:** Data curation, Writing-Original draft preparation, Software, Validation. **Ali Ulvi:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

There is no conflict of interest.

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