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Comparison of photogrammetric software using the terrestrial photogrammetric method: The case of Hüsrev Paşa Mosque

Fatih Pulat *[1], **Murat Yakar** [2], **Ali Ulvi**[3]

[1]Siirt University, Department of Architecture and Urban Planning, Map and Cadastre Program, Siirt, Türkiye
[2]Mersin University, Faculty of Engineering, Department of Surveying Engineering, Mersin, Türkiye
[3]Mersin University, Department of Geographic Information Systems and Remote Sensing, Mersin, Türkiye

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Abstract
From the past to the present, very few cultural artifacts have survived to the present day by preserving their own characteristics. These artifacts undergo structural deterioration due to the destruction they have suffered as a result of natural events, the damages caused by human hands, and since the necessary repairs have not been made in accordance with their structural characteristics, although they are under protection, so they are devastated and demolished. In this study, the detail measurements of the Hüsrev Paşa Mosque, which is located in the Merkez İpekyolu district of Van province and which has survived as a work of Mimar Sinan, were made with the terrestrial photogrammetric method in three dimensions, and the pictures of the building were taken. Thus, by evaluating the data obtained in the computer environment, it is aimed to obtain a three-dimensional model with all the building details such as the size, type of structural material, and visual of the building for every desired point on the building. In the study, comparison will be made using different photogrammetric software.

1. Introduction

It is aimed to keep the cultural and natural assets alive by taking many precautions to protect them and to transfer them to the next generations. In line with this purpose, all kinds of technological developments brought by the age lived since the past have been followed. The most fundamental element in the protection and preservation of cultural and natural heritage is the preservation of the structural integrity of the property. When we look at the assets that have not preserved their structural integrity, natural disasters such as earthquakes, floods, landslides, weather events such as wind, storm, rain, and human-made damages intentionally or unintentionally (intentional damages and unintentional damages during renovation-repair) are the reasons why the structure has not survived until today. and is one of the biggest reasons why it cannot be passed on to the next generations. Another major reason for this destruction is 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.

1.2. Resources Research

In the light of the technological developments experienced today, it is necessary to protect our cultural heritage both structurally and digitally record all the norms and features (shape, size, detail, building material, etc.) of the building. In this sense, there are many techniques developed for the preservation and survival of cultural heritage. One of these techniques that is widely used is photogrammetry technique. Thanks to the photogrammetry technique, all assets subject to cultural heritage can be geodesically measured with all their detail points, and a three-dimensional model can be obtained by combining the images obtained by the picture shooting process. Photogrammetry is the creation of a three-dimensional model of any object or structure with pictures and determining its location (Kraus, 1993).

In parallel with the continuous development of technology in our age, photogrammetry technique has also shown continuous improvement. Analogue methods have been replaced by analytical photogrammetry, especially with the development of cameras and the use

* Corresponding Author

*(fatih.plt.65@siirt.edu.tr) ORCID ID 0000-0002-4043-9654
(myakar@mersin.edu.tr) ORCID ID 0000-0002-2664-6251
(aliulvi@mersin.edu.tr) ORCID ID 0000-0003-3005-8011

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of computers. With the developments in the digital sense in a short time, the photogrammetry technique has also developed rapidly, and today, wearable technologies with laser scanners, unmanned aerial drones (UAVs), mobile vehicles with terrestrial laser scanning are experiencing a very strong age in terms of technology (Caglayan, 2020).

1.3. Local Photogrammetry

Photogrammetry can be studied in three main steps by looking at its components. These steps are listed as obtaining the data, evaluating the data, and obtaining a final product by utilizing these data. These steps are also valid for terrestrial photogrammetry (Hanke and Grussenmeyer, 2002).

The most important part of these steps is the acquisition of data. The data obtained in this step are of two types. These data are; triangulation, polygon etc. established in the field and called ground control points. These are the measurement data obtained based on geodetic points such as geodetic points and photographic data obtained by taking pictures (Karslı, 2016).

Figure 1. Digital cameras used in terrestrial photogrammetry

2. Method

The work on which the study will be carried out is located in the south of the old city of Van, within the borders of the historical Van Castle, which dates back to 840 BC from the Urartian civilization. The work was commissioned by the Governor of Van, Köse Hüsrev Pasha, in 1567 by Mimar Sinan, one of the most famous architects of his time and one of the best architects of all time. Hüsrev Pasha Mosque is square in shape and was built with a large dome on thick walls. The walls of the work are made of cut stone and squinches, and the dome is made of brick. Today, it has still managed to preserve its beauty and robustness to a large extent.

Figure 2. Study area

The method used in this study is called the terrestrial photogrammetry method. In this method, studies are carried out in a place-based manner. Aim; is to produce a 3D and measurable model of the work by using the 2D photographs of the work and the measured points on the work.

Scope of the study, photographing and measuring processes of the work were carried out in the field. Obtained 3D point data using Netcad 5.1 software, Photomodeler UAS and Agisoft It has been evaluated to provide base data for Metashape software. This data, together with the uploading of the photographs of the work to the software, 3D drawing and point production were provided, and a 3D model of the work was obtained through both software.

Terrestrial photogrammetry work consists of successive stages within the discipline, starting with the work in the field and ending with the office work in the office environment. The work flow chart showing these stages is given in Figure 3.

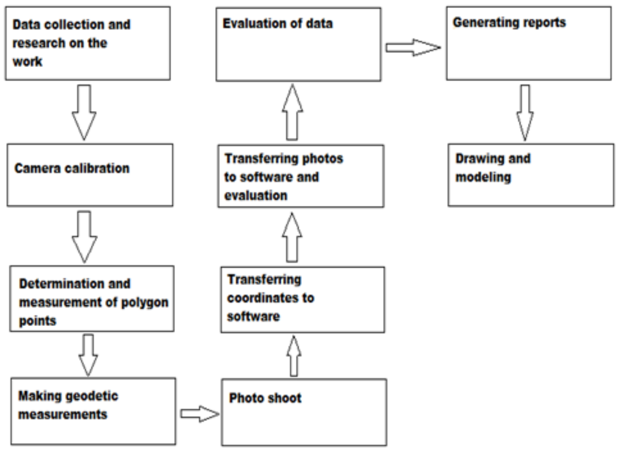

Figure 3. Work flow chart of the study

2.1. Office Studies

2.2. Photogrammetric Drawing Stage of the Artwork with Photomodeler UAS Software

The measurement values obtained from the field were transferred to the computer environment and recorded in Netcad 5.1 software. ncn file format for later evaluation in Photomodeler software. txt format has been converted. 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.

In Photomodeler UAS software, the work of obtaining a 3D model was started by creating a point cloud in the same software. After the selection of parameters related to the sensitivity of the work, the photos of the work are uploaded to the software, respectively. detection (feature detection), matching (matching), matching and Marking (matching and marking), orientation (orientation) operations are done.

Thus, as a result of the process, a point cloud consisting of 61337 3D points belonging to the work was obtained. Using the generated point cloud 3D viewer options menu, surface and point mesh parameters were determined.

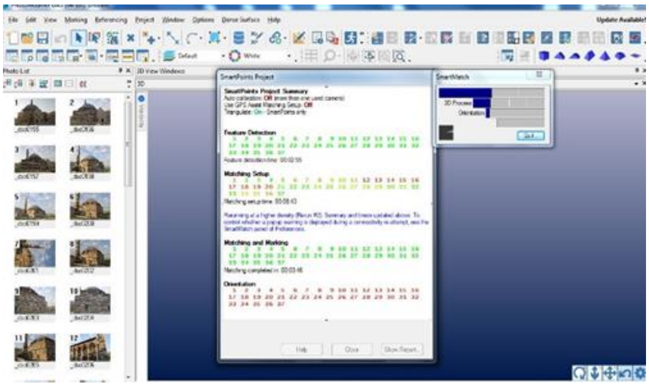

Figure 4. Point cloud generation phase

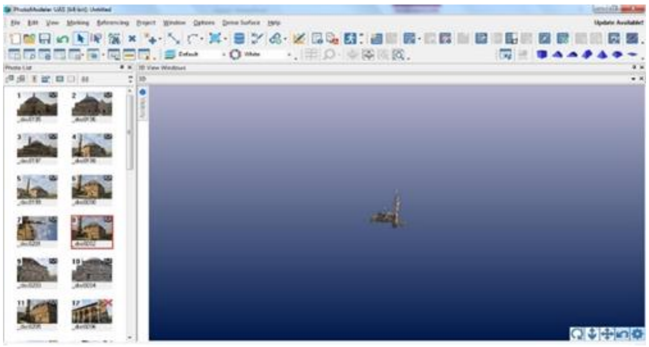

Figure 5. Model created with sparse point cloud

It has been observed that the point cloud of the 3D model obtained with the sparse point cloud does not have a homogeneous structure, so an even sparse point cloud is obtained in some parts of the work. In order to obtain a dense point cloud of the work, a dense point cloud surface was created by using the ' Create Dense Surface ' tab of the 'Dense Surface ' menu by selecting the photos with even less sparse point cloud over the software.

In order to create the dense point cloud, the number of dense point clouds created for a selected surface of the work was 447,063 and the creation time took 2 minutes and 5 seconds. Thus, a 3D model of the artifact was obtained by obtaining dense point clouds belonging to each surface.

2.3. Photogrammetric Drawing Stage of the Artwork with Agisoft Software

To the work After the field operations carried out on the land belonging to the company, work began in the office environment. Agisoft , the latest version of Agisoft software First of all, camera calibration processes were performed with Metashape software. In order to calibrate the camera, at least 3 photographs of the checkerboard calibration test paper taken from different angles must be used. For this study, 12 photographs of the camera calibration paper taken from different angles were used.

Photographs of the work after the camera calibration processes Agisoft The evaluation phase was started by transferring it to the Metashape software. This evaluation phase is on the Add Workflow menu on the software. It is done with the Photos command.

With the transfer of the photos to the software, the alignment of the photos is done by clicking the Align tab on the Workflow menu. Here, the frequency of the point cloud to be created and the features of the photographs to be studied are determined by choosing the appropriate parameters according to the nature of the work to be done and the desired sensitivity.

Alignment _ After the Photos) process, the control points marked and measured on the artifact were loaded into the software, and matches were made with the marked points on the artifact very precisely.

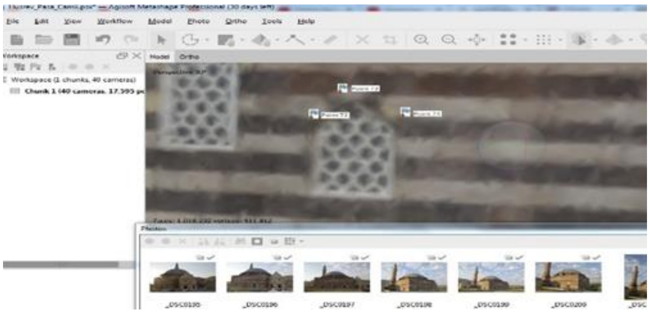

Figure 6. Matching points

After the point matching process, a point cloud was obtained by tightening the points of the artifact by clicking on the Build Dense Cloud tab from the Workflow menu to tighten the points on the artifact.

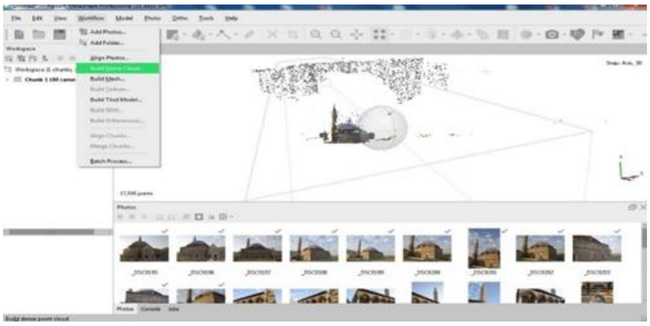

Figure 7. Point cloud

The solid model obtained from the work will be able to have its real texture with the painting process. Therefore, texture coating processes are started by clicking Model Shaded and then model textured on the software. (Fig. 8.). As a result, a 3-dimensional model of the work is obtained (Fig. 9.). The file of the model can be viewed in 3D with different software by obtaining the 3D file with the Export Model operation from the File menu.

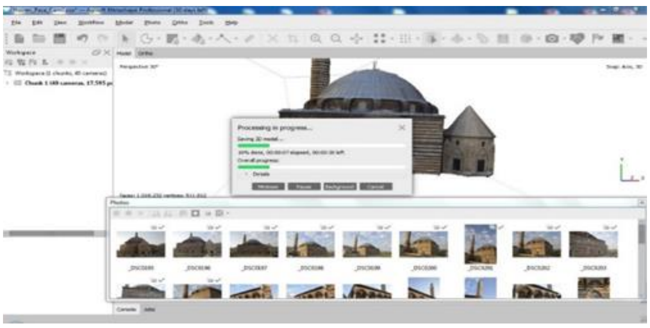

Figure 8. The texture coating process of the work

Figure 9. 3D view of the work from different angles

3. Results

V max, V min and V avg values in the x, y and z directions of the location data of both software were determined and position error were calculated.

$$m = \pm \sqrt{ [\, vv \,] / (n-1) } \quad (1)$$

$$m (xyz) = \pm \sqrt{ (m x 2 + m y 2 + m z 2) } \quad (2)$$

Table 1. Coordinate differences obtained from software

	Photomodels UAS				Agisoft metashape		
	Vi Differences (cm)				Vi Differences (cm)		
	Vx (±)	Vy (±)	Vz (±)		Vx (±)	Vy (±)	Vz (±)
vmin	0.1	0	0.3	vmin	0.1	0.4	0.5
Vmax	7.1	4.1	2.8	Vmax	4.9	3,4	3
vort	1.9	1.7	1.5	vort	1.7	1.6	1.6
	VxVx	VyVy	VzVz		VxVx	VyVy	VzVz
	181.42	146.69	115.33		158.77	137.66	130.89
m	2.2	1.8	1,2	m	1.7	1.9	1.1
m(xyz)(±)	3.08			m(xyz)(±)	2.78		

Agisoft in terms of the calculated mean square error and position error of the data obtained through both software. It has been determined that the data obtained from the Metashape software are more sensitive data (Table 1). In addition, the 3D model obtained by Photomodeler UAS and Agisoft The data on the number of sparse points, the number of dense points and the creation times of these point clouds are given in Table 2 comparatively.

Table 2. Data of the 3D model obtained from the software

	Photomodels UAS		Agisoft metashape	
	Sparse Spot	Dense Spot	Sparse Spot	Dense Spot
Number	61,337	6.675.987	17,595	5.168.153
Total Number of Points	6.737.324		5.185.748	
Pairing Time	00:20:02	00:18:38	00:03:26	09:50:08
The total time	00:38:40		09:53:34	
Used your computer Properties	Intel Core 2 Duo Processor		237Gb _ Hard Disk Capacity	
	2.0 GHz Processor Speed		Windows 7 64 Bit Operating System	
	2.0 RAM			

As seen in Table 2, Agisoft While the total number of points produced in the Metashape software was 5,185,748, the total number of points produced in the Photomodeler UAS software was 6,737,324. Thus, the number of dots produced in Photomodeler UAS software It has been observed that the Metashape software creates extra points, approximately 30% of the number of points. This shows that more detail points can be obtained with Photomodeler UAS software, especially in the modeling of artifacts with intense detail features, and the features of the artifact can be modeled better.

4. Discussion

Photomodeler UAS software from Agisoft Another advantage over Metashape software is that this software allows 3D modeling in the form of hand drawing. Making manual drawings in Photomodeler UAS software is one of the extra advantages of this software. In addition, it has been observed that the lines of the building model obtained by hand drawing are smoother and sharper than the lines of the model obtained through the point cloud. This is the point of the modeling work of this work, considering the time and effort spent on drawing, the parts (minaret) of the work that cannot be measured and photographed, although the software provided an advantage in the drawing phase, since the work that is the subject of this study has a relatively flat architecture. Creating the cloud creates a greater advantage.

5. Conclusion

The terrestrial photogrammetry technique applied in the study area, and the measurement processes, especially together with the laser measuring instrument, enabled the study to be carried out much faster than the classical methods, to require shorter time, to be carried out with less personnel and less costly equipment. It is seen that the precision quality of the measurement results obtained with both software is high, but compared to each other, Agisoft It was determined that the Metashape software gave better results (Table 1).

The measurement results obtained were compared and it was determined that the error amount of the measurement process made with the total station measuring instrument was below 5 mm, thus giving more accurate results than the GPS measuring instrument. The building does not have complex surfaces, but generally has a flat surface. This has been an important factor in keeping the amount of error low in drawing processes.

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