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Modeling of historical fountains by using close-range photogrammetric techniques

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ABSTRACT

It is inevitable to see historical monuments in every geography where man exists. Most of the architectural monuments that have witnessed history have been completely or partially destroyed for different reasons. Especially natural disasters such as earthquakes, floods, and fires, as well as wars, misuse and unconscious use cause these damages. Architectural monuments bearing the traces of history are one of the most important means of transferring history to future generations. The preservation and transfer of this cultural heritage to new generations are one of the common tasks of all peoples in the world. In this context, with the developing technology, efforts to document the cultural heritage in the digital platform in 3D have accelerated. There are many 3D modeling methods in the literature. Photogrammetry technique, which is one of the 3D modeling methods, enables us to create photo-realistic models. The photogrammetry technique gives more meaningful results in terms of speed and accuracy compared to traditional methods. This study involves the production and documentation of a 3D model of historical fountains by using close-range photogrammetry.

1. INTRODUCTION

Historical artifacts are a cultural heritage that includes all experiences from past to present. Cultural heritage is a historical monument with certain criteria (witnessing a different tradition, the product of creative human genius, representing one or more, etc.), that are protected and transmitted for the benefit of future generations (URL1). Cultural heritages represent the bond between people from the past to the present and to the future. Cultural heritage reflects the history and essence of humanity and ensures the continuity of traditions and diversity. Cultural heritage can contain many concepts. A cultural heritage that reflects the dusty pages of history can be grouped under three main headings: concrete, abstract and natural cultural heritage.

Tangible Cultural Assets: It is divided into two groups as movable and immovable heritage. Monuments, sculptures, paintings, archaeological works, inscriptions, books, landscapes and so on.

Intangible Cultural Assets: Folklore, traditions, language, oral history, etc.

Natural Heritage: Culturally important landscapes and biodiversity (URL2).

2. THE IMPORTANCE OF DOCUMENTATİON OF HİSTORİCAL ARTEFACTS

Ever since humanity began to play a role in the history scene, artifacts that trace of history in every geography has emerged. There are more historical monuments, especially in areas where access to minimum living requirements and opportunities (food, housing, education, etc.) is easy. Therefore, as the cradle of civilizations, there are many cultural and historical heritages on Anatolian lands. Documentation and preservation of cultural assets that have hundreds of years of knowledge of many peoples and which must be hand down the next generations are indispensable (Uslu et al, 2016).

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Throughout history, due to the, and natural richness it has housed, different communities have existed in Anatolia. In Today's in the Republic of Turkey (Anatolia Region) at the end of the year 2018, by The Ministry of Culture and Tourism 108813 units, the immovable asset was registered as a cultural asset.

Table 1. 2018 year-end distribution of immovable cultural assets located in Turkey (URL3)

The registered immovable cultural property in Turkey	Real estate count
Example of Civil Architecture	69.104
Religious Structures	10.147
Cultural Structures	12.53
Administrative Structures	2.985
Military Structures	1.252
Industrial and Commercial Structures	4.171
Cemeteries	5.169
Martyrdoms	307
Monuments And Landmarks	375
Ruins	2.702
Streets Protected	71

Destruction of cultural heritage due to natural disasters or human factors, making recompenses as a result of damage, knowing where they belong to the missed works, preserving their original features and keeping them back in their original places is very important (Demirkesen et al, 2005). It is possible to transfer historical works including all phases of history and giving us any clues about history to future generations through healthy documentation. Documentation of historical or cultural structure covers the entire steps which are necessary for determining the current state of the structure (shape and position) in three-dimensional space that are surveys, process, storage and presentation (Georgopoulos and Ioannidis, 2004).

3. DOCUMENTATION METHODS

Documentation can be defined as the determination of the current status of cultural assets in different scales and qualities (drawings, plans or other graphic narration, photographs, digitized documents, etc.). Information about the state of the structure or area at the time of study and the documentation stage at which the document is produced form the basis of the whole process. Today, different techniques are used in the documentation of cultural heritage and this issue is developing rapidly in parallel with technological developments. In addition to producing information on various physical, social, economic, cultural and historical aspects of cultural assets in different qualities and scales, processing and converting the produced data into usable information is an indispensable requirement for protection. General documentation techniques are shown in figure 1 (Pakben, 2013).

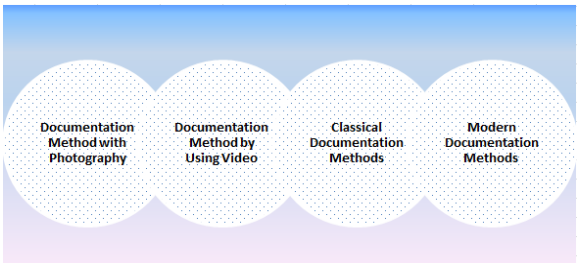

Figure 1. General documentation techniques

3.1. Documentation Method with Photography

Photography is a means of communication. The rules for detecting messages also apply to the detection of a photo. It is natural for people living in different cultures to perceive the same message differently. Especially the indicators with symbolic meanings have different meanings according to cultural characteristics (Bodur, 2006).

As a visual text, the product photo should be able to identify the product correctly and effectively. The effective use of photography forms the basis of visual communication (Grill and Scanlon, 2003). The purpose of documentation with the photograph is completed by taking a large number of photographs from general photographs of buildings (facades, building environment, etc.) to detailed photographs (interior and exterior photographs).

3.2. Documentation Method by Using Video

It is possible to document structures with video shooting. The surroundings, facades, and interiors of the building are visited and recorded. During this recording, shooting should be performed with an as little shake and heavy motion as possible. Thus, the details of the structure can be seen clearly in the video.

3.3. Classical Documentation Methods

The idea of protecting cultural heritage has emerged for the measures taken for the protection, renovation, and restoration of historical monuments. With the development of technology, the techniques used to document historical artifacts for many years started to be known under the name of classical techniques.

- Linear Documentation
- Written Documentation
- Graphic Documentation
- Information Sheet

Classical documentation techniques are can be collected under the above headings.

3.4. Modern Documentation Methods

Modern documentation techniques are frequently preferred by different disciplines when traditional methods are inadequate in the documentation of historical monuments. Particularly facade silhouettes, building decorations, 3D documentation on digital platform and so on. It would be more accurate to use modern methods for their work.

Modern documentation methods are divided into photogrammetry and laser scanning. In our study, the close-range photogrammetry method, which is one of the photogrammetric methods, was preferred.

3.4.1. Documentation with close-range photogrammetry method

Photogrammetry is a successful documentation method that especially has accuracy, flexibility, and practicality. As an indispensable part of restoration projects, drawings related to the current situation (detection drawings) can be obtained by the photogrammetric method accurately and reliably in a short time. Also, with this method, analytical documentation (materials, distortions, authenticity, etc.) can also be used for studies.

The close-range photogrammetry technique has been used for archaeological surveys and documentation of historical monuments for many years. With the development of digital techniques, photogrammetry has become a more efficient and economical method for the documentation and preservation of architectural works. In recent years, as a result of developments in digital photogrammetry and computer technology, the creation of a 3D model of buildings has been among the current research topics. 3D building models are becoming increasingly compulsory for urban planning and tourism. (Suveg and Vosselman, 2000).

The 3D photo modeling used in this study is very effective in understanding terrestrial objects that are actually inaccessible. The use of photo models from existing objects facilitates the understanding of complex terrestrial structures (Dorffner and Forkert, 1998).

4. MATERIALS AND METHODS

Nikon D3100 camera (fig. 3), Cygnus Topcon KS-102 non-reflector total-station (fig. 2), and PhotoModeler UAS software, which enables 3D drawing and point cloud production from photographs, are used as the hardware.

Figure 2. Cygnus topcon ks-102 total-station

Table 2. Nikon D3100 Technical Specifications

Sensor size	23,1 x 15,4 mm
Total megapixels	14.80
Max. image resolution	4608 x 3072
Weight	505 g
Dimensions	124 x 96 x 75 mm
Pixel density	3,99 MP / cm^2

Figure 3. Nikon D3100 photograph cameras (URL4)

Planned geodetic measurement and photographing should be performed in order to make 3D modeling with the digital photogrammetric method. For geodetic measurement of the control points on ancient artifacts to be used in the photogrammetric evaluation, a geodetic network that covers the object completely in all aspects should be established primarily in such terrestrial photogrammetric and modeling studies.

In this context, a geodetic network has been established in the local coordinate system to cover the historical structure completely from all directions. In selecting the control points where the measuring device will be installed, the locations that will see the structure fully are preferred. Considering the physical properties of the surface of the structure, attention was paid to the selection of sharp lines and clear control points (Uysal et al, 2015).

The stage of taking photographs of the historical fountain was made from different angles according to the convergent shooting principles, taking into account that at least four photographs were included for each detail point. The photographs were taken from different angles on the days and times when the structure and weather were suitable. With the double-image photogrammetry method, each photograph is overlapped with other photographs with common target points and is referenced to each other. There were no situations in front of the building that would prevent the building or any part of the building.

5. STUDY AREA

Figure 4. Study area and Sultan Water Fountain

Taşkent is a small town situated on the Göksu valley canyons on the Taşeli Plateau in the Middle Taurus Mountains. 135 km of Konya province about 100 km south of the Mediterranean coast away, located in the Mediterranean region. Sultan Water Fountain N 36 ° 55'17.5 "E 32 ° 29'25.7" is located in the coordinates (URL5).

Information on Sultan Suyu Fountain from the 110th page of the journal "Mecmuatül Tevarî-Ül Mevleviye", which was published in 1203 in the form of the official newspaper of the time, found in the Directorate of Konya Antiquities Museum (URL 6) is available. Also information from local residents is available. According to this information, the first state of the fountain was made during the Anatolian Seljuk Sultan Alaeddin Keykubad (1192-1237). Later, in 1982, it was learned that the single-arched section in the middle of the fountain was built and in 1998 the present state was made.

6. APPLICATION of PHOTOGRAMMETRY in ARCHITECTURAL STUDIES

Data processing in the photogrametry consists of coordinate calculations and generating a 3D model. Coordinates of points are calculated in a local system with surveying and leveling. Basically, all detail points of the structure measured with Total Station equipment are transferred to the computer. In Netcad software, the 3D coordinates of the point are calculated. In the fieldwork some surveys are made for controlling the detail points as the same detail point is observed from different polygon points. At the end of all calculations and controls, the coordinates of points are saved in .txt format. Camera calibration parameters of the Canon D3100 camera are calculated in PhotoModeler software and saved as a .cam format. For absolute orientation, the .txt and .cam files are used (Uysal et al., 2013).

Checkpoints that appear in two or more images are marked because the PhotoModeler software performs mutual and absolute orientation at the same time (Yastıklı, 2013). After marking the control points, a photograph was selected as a reference and matching of each control point was shown in the other marked photos.

After that, the orientation process was done according to the bundle method in PhotoModeler software. The orientation results using 45 photographs are shown in figure 5.

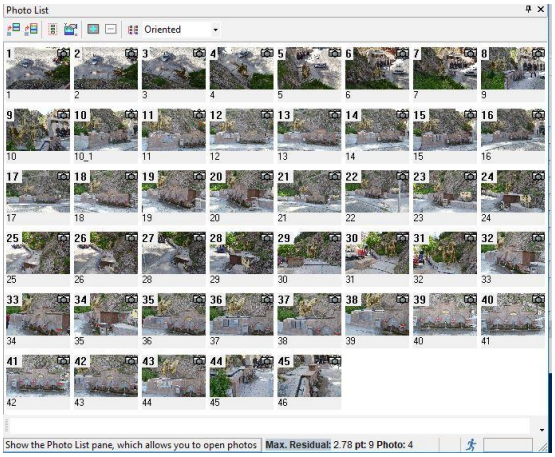

Figure 5. The result of the orientation

After the orientation process, 3D model production was started.First, the details of the pairs of the same detail were drawn (fig.6-7) and the skeleton of the fountain was completed (fig.8).

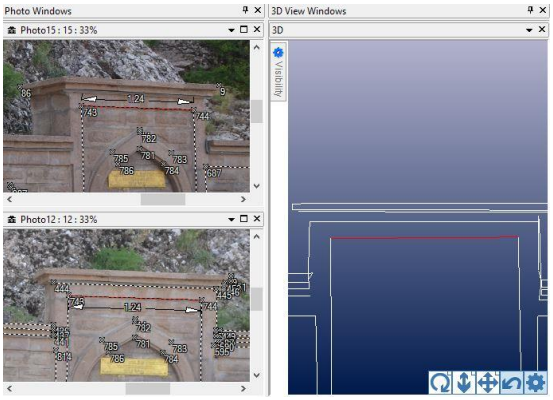

Figure 6. Detail drawing

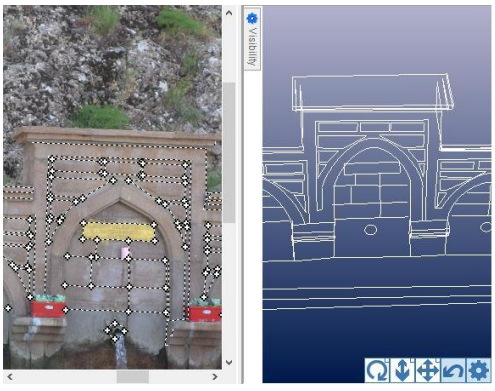

Figure 7. Detail drawing

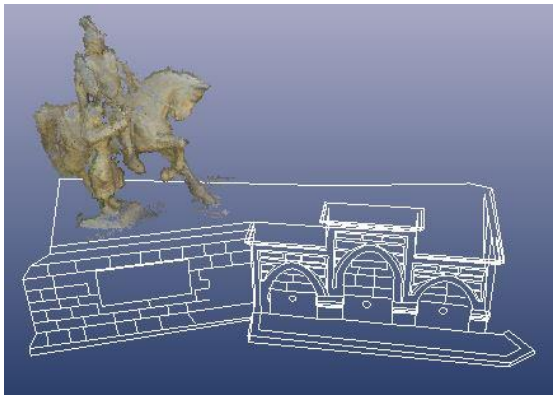

Figure 8. The basic skeleton of the Sultan Water Fountain

Afterward, texture coating was performed on the basic skeleton (fig.9).

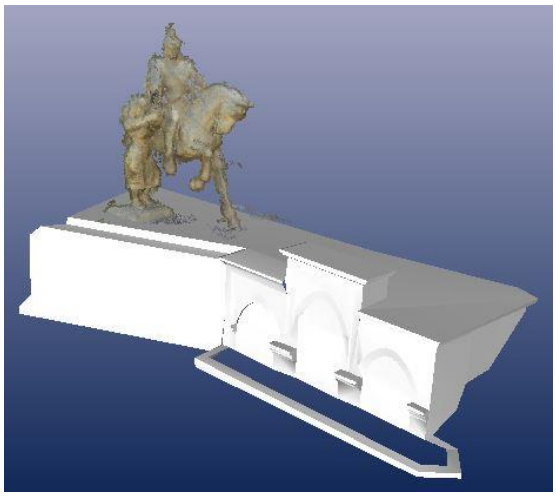

Figure 9. The 3D shaded model

As a result of all processes, a 3D model of the historical Sultan fountain was produced on the digital platform and the documentation work was completed (fig.10).

Figure 10. 3D model of the Sultan Water Fountain

7. CONCLUSION

The use of advanced technologies in the documentation of historical and cultural heritage is necessary to achieve accurate and high precision and fast and effective results. The vector study is not always sufficient to document the details of the historical monument and to collect all the details of the structure. Advanced documentation techniques allow for precise accuracy of the survey of sections of complex geometry (dome, arch, etc.) encountered in historical buildings.

It is advantageous to use photogrammetric methods instead of traditional methods that require long and laborious measurements especially in the documentation and evaluation of stone surfaces and high structure. In the photogrammetric documentation of historical buildings, all the details on the building can be handled together and as a whole. This makes it especially easy to produce the necessary bases for the hand down and documentation of historical buildings to the next generations. In addition to three-dimensional vector data by photogrammetric methods, texture data is also provided. This data is very important in terms of giving the real appearance to the objects to be re-formed in three dimensions and increasing the comprehension of the user. This texture data reflects the geometric properties of three-dimensional objects, ie the metric properties are overlapped with vector data. Since these textures are taken from the photos of the building, they create more realistic models.

It is seen that three-dimensional models produced using photogrammetric techniques can be used as a source in restoration projects and this model can also export VRML format to be used in different applications (Carry and Bell, 1997).

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