

DIGITAL TECHNOLOGIES IN DOCUMENTING THE CULTURAL HERITAGE REVIEW OF LASER SCANNERS

*Hassani Fereshteh*¹

ABSTRACT

Cultural heritage is counted as an irreplaceable source of human. This special and unique source is always confronts dangers and threats such as natural disasters. Hence historical buildings may always change and be ruined due to these threats. These cases emphasize on the necessity of precise documenting and recording of cultural heritage. In documentation process of monuments a variety of tools and methods are used. But alongside the human progress and the emergence of new tools in different sciences, the documentation techniques of historical buildings have changed and new digital technologies are used in this field. One of these digital technologies is laser scanner which using it has had a growing trend in recent years.

In this paper the need for documenting the cultural heritage and recording them and then digital technologies used in them will be studied. Then considering this point that using each tool has its own principles and it is necessary to recognize them; laser scanner, how to use it, its advantages and disadvantages and limitations will be surveyed.

This research aims to inset the usage of laser scanner in documenting the cultural heritage owing to optimum use of it.

Keywords: Cultural heritage, Documentation, Digital technologies, Laser scanner, Survey

1. INTRODUCTION

Historical buildings are the identities of human beings. They are the heritage of our ancestor and show their life styles and technologies used by them. Thus preserving and maintaining of these works has a specific important. But the first step in preservation of these precious works is always to make a precise documentation of them. Identification and documentation of historical monuments and sites are done in many ways and along with the advancement of science and technology, these methods will be changed and developed. Nowadays digital technologies are widely used in documentation of historical buildings and sites.

In this paper first the importance of cultural heritage documentation, then various techniques of doing it will be reviewed. Afterwards laser scanner, how to use, advantages and disadvantages, the limitations of using it will be studied.

With respect to the existing circumstance of each case, the study of different techniques is very important to select the best way of documentation. Getting familiar with these techniques is specially very essential for cultural heritage experts. In fact a bridge should exist between surveying and cultural heritage experts to achieve better results.

¹ Master degree student of Architectural and Urban Restoration, Architecture and Urban Planning Faculty, Shahid Beheshti University, Tehran, Iran, hamisheh.65@gmail.com

2. THE NEED FOR DOCUMENTATION OF HISTORICAL MONUMENTS

Prior to any measurement about cultural heritage, precise study and documentation must be done.

“Recording is the capture of information which describes the physical configuration, condition and use of monuments, groups of buildings and sites, at points in time, and it is an essential part of the conservation process” [1].

Documentation leads to better understanding and perception of cultural heritage and finally to make the right and proper decision about how to protect them.

Also, since cultural heritage are always in danger of change and even destruction due to deterioration over time, human damages and natural disaster such as earthquake, it is essential to document and record them in an accurate and detailed way. This way they can be repaired, restored or reconstructed if needed.

As an example Bam Citadel which was considered as the largest earthen complex in the world; was ruined because of the 2003 earthquake. But considering this point that there was no proper document, reconstruction of it encountered many problems.



Fig. 1 Arch net, Digital Library, Citadel of Bam, general view, prior to the earthquake.

Redrawn from https://archnet.org/library/images/one-image-large.jsp?location_id=9661&image_id=61618



Fig. 2 Arch net, Digital library, Citadel of Bam, general view, post-earthquake

Redrawn from https://archnet.org/library/images/one-image large.jsp?location_id=9661&image_id=188046

In addition to all of these points, precise recording of historical monuments will result in growing the awareness of people and managers and therefore enhancing the sensitivity of preserving the cultural heritage values.

The 16th article of Venice Charter emphasizes on the need of documentation and preparing reports of all of preservation stages:

Article 16: in all works of preservation, restoration or excavation, there should always be precise documentation in the form of analytical and critical reports, illustrated with drawings and photographs. Every stage of the work of clearing, consolidation, rearrangement and integration, as well as technical and formal features identified during the course of the work, should be included.

This record should be placed in the archives of a public institution and made available to research workers. It is recommended that the report should be published' [2]

3. THE NEED FOR UNDERSTANDING DIGITAL TECHNOLOGIES AND USING THE IN DOCUMENTATION CULTURAL HERITAGE

In documentation of historical buildings different techniques and methods are used. With the advancement and development of various technologies in today's world, the use of digital technologies in this field has grown considerably. So it is necessary to know and review these tools and the facilities which they provide for heritage authorities.

According to the article 2 of Venice Charter, we should take advantage of all the sciences and technologies which can be useful somehow in cultural heritage field:

“Article 2: The conservation and restoration of monuments must have recourse to all the sciences and techniques which can contribute to the study and safeguarding of the architectural heritage”.

Thus the need for using modern digital technologies in studying and documenting cultural heritage is legitimized.

But the case of selecting proper tool and technique is also very significant. Each of used tools has its own advantages, disadvantages and limitations. So considering the important factors such as time and cost the correct tool and way for documentation should be chosen to achieve better result.

4. INTRODUCING DIFFERENT TECHNIQUES OF DOCUMENTATION

In the documentation and recording historical monuments and sites, preparation of plans is performed in a macro level (building and its surrounding area) or in a micro level (the building itself and its complications). In the surveying of larger areas, plans with smaller scales are provided. Documentation of these cases is done with the help of aerial photogrammetry.

In processing the plans of buildings and limited areas, the scales are larger and more detailed are provided. In preparing these plans, the building complications are also recorded very carefully. But providing these kinds of plans are performed in different ways. Which can be categorizes into 4 groups:

4.1. Surveying with the use of simple tools and drawing plans manually

In this method first a sketch of the building is drawn. Then all the measuring of the building carried out by using simple tools such as a meter and the measurements are recorded on the sketch. Finally using the measures a detailed drawing will be performed. This drawing was done by the surveyor on the paper in the past, but then some drawing software such as Autocad became useful.

But this method has very low accuracy and is also timeconsuming. In some surfaces (such as curved surface) are difficult to measure and the result has not enough accuracy. In addition in the surfaces with high level complexities this method does not work.

4.2. Surveying with the help of high-precision accurate tools

This technique is performed using tools such as total stations.

The tachometric survey, or the determination of single polar points, has been consistently the further development ever since the existing of total station. As a quick automated determination of prominent single points, sections, and profiles, it provides outlines of difficult objects with curve surfaces, meanwhile reducing the access needs. In the meantime, it can produce 3D wire frame-modelling with high absolute point accuracy. The point accuracy, even in surveys of extensive, complex objects with curved surfaces, is with a few millimeters comparatively very good and homogeneous, practically independent of the size of the object. [3]

However it is time consuming, needs high skills operation and low in efficiency for surveys of surficial and complex forms with a large number of points. Two types of instruments are available: Total Stations that are manually aligned to the target point and those that are equipped with servomotors, and are externally controllable from a laptop. Conceptually, total stations, with notable exceptions, because of their cost and the complexity of their use and maintenance. [4]

In this technique in the case of incomplete surveying by operator, the data are not enough. Therefore the documentation is inaccurate and for its completion the field research will be needed and it should be performed again to fulfill it.

4.3. Close range photogrammetry

The base of photogrammetry is the extraction process of dimensions by using photographs. In this technique high resolution metric cameras are used and couple photos are taken of the subject. Each of these couple photos should have also proper overlap with each other. Finally with the help of some software program such as photo modeller and these photos, the process providing 3-dimensional model of the subject will be performed.

Considering this point that the photos have been taken by metric cameras, they can be interpreted and produce the 3D model with exact dimension and scale and in such a high accuracy.

4.4. Laser scanners

Laser scanning technology with its automated data capture capabilities is bringing new perspectives and can satisfy most requirements of this type of applications. 3D laser scanning represents today the most advanced technology available for measuring and documenting objects. [5]

Laser scanners can measure and produce thousands of points per second based on the run-time of reflected light pulses. The resulting three dimensional color point cloud can be used to extract CAD elements or – by using point triangulation – to create a 3D surface model [6]

Laser scanners can be used for surveying buildings and objects (for example statues) with high complexities.



Fig. 3 A kind of laser scanners

Redrawn from <http://www.gisementiran.com/docs/tajhizat.htm>

4.4.1. Laser scanner way of work

Laser scanner way of work is totally identical to the total station devices, with the difference that the surveying process of laser scanners are performed automatically.

These devices have two rotational axes in both horizontal and vertical directions and can survey the entire area they covering (according to the device structure). With respect to the specified angles horizontal and vertical axes relative to the internal coordinate axes of the system and measuring the distance by the laser scanner, the coordinate of each point by the system (or the connect computer to it) is calculated. [7]

Production phases of a 3D model by using a laser scanner can be categorized in 4 stages:

1. Measuring
2. Point cloud
3. Alignment
4. Merging

4.4.1. Advantages and disadvantages

Laser scanners are very good for measuring, analyzing and modeling complex surfaces. High speed of these devices in measuring points is one their most important features. Thus field measurements are conducted very quickly by them and other works can be performed in the office.

Since the laser scanner operation is based on the direct of beam to the subject, so in this case for example, even dust can also be documented so the point cloud model has lots of noises and in converting it to the surface model, it may be some holes in the surfaces. Therefore, more time should be spent to process points and making a point cloud model and eventually turning this model to the surface model.

Also handling the operation due to greate amount of data is another problem which can be noted.

5. CONCLUSION

The article reviewed different techniques of documentation of cultural heritage.

The methods of recording and type of documentation produced should be appropriate to the nature of the heritage, the purposes of the record, the cultural context, and the funding or other resources available. Limitations of such resources may require a phased approach to recording. [8]

Besides size and complexity, other factors may influence the optimal method to be chosen. These include: the necessary accuracy and resolution; accessibility of the object and availability of ideally located vibration-free observation stations; availability of instruments and power supply; and the possibility of touching the object and permission to use the selected method. For large objects (monuments, sites, etc.), architectural mapping, regular topographic surveys and laser scanning are used along with photogrammetric techniques. [9]

So with respect to the existing circumstance of each subject, laser scanners are not enough for documenting cultural heritage. For example when facing cracks and very small details laser scanners can not be useful, or when we the budget of documentation is low we should use another method of documentation.

But regardless of the time and cost, and when accuracy is the important factor; the combination of two methods of laser scanning and photogrammetry to achieve best results is necessary due to neutralizing each other's weaknesses.

REFERENCES

- [1] ICOMOS Principles for the recording of monuments, groups of buildings and sites, Sofia 1996, Petzet, M. Ziesemer, J. Ed. International Charters for Conservation and Restoration, Monuments and Sites I ICOMOS.
- [2] ICOMOS Venice Charter 1964, Petzet, M. Ziesemer, J. Ed. International Charters for Conservation and Restoration, Monuments and Sites I ICOMOS, Munich 2001, pp. 13-14.
- [3] Harrison, E. (2002) How should we measure an ancient structure?, Nexus Network Journal 4, 18-24, <http://www.springerlink.com/content/7750412312100410/>.
- [4] A. Haddad N. (2011) Review from ground surveying to 3D laser scanner: A review of techniques used for spatial documentation of historic sites, Department of Conservation Science, Queen Rania Institute of Tourism and Heritage, Hashemite University, Zarqa 13115, Jordan, Journal of King Saud University – Engineering Sciences, 109-118.
- [5] Haddad N. & Akasheh T. (2005) Documentation of archaeological sites and monuments: Ancient theaters in Jerash, CIPA 2005 XX International Symposium, 26 September – 01 October, Torino, Italy.
- [6] Boehler, W., Heinz, G., Marbs, A. 2005 The potential of non-contact e range laser scanners for cultural heritage recording In: ciosProceedings of CIPA XXth International Symposium, September 26 October 1, 2005, Torino, Italy, 430-435.
- [7] D. Moghaddam A. (2009) Providing 3 dimensional models of historical buildings using laser scanners, <http://www.gisementiran.com/docs/images/m1.pdf>.
- [8] ICOMOS Principles for the recording of monuments, groups of buildings and sites, Sofia 1996, Petzet, M. Ziesemer, J. Ed. International Charters for Conservation and Restoration, Monuments and Sites I ICOMOS.
- [9] Patias P. (2006) Digital Recording and 3D Modeling, Cultural Heritage Documentation, International Summer School Aghios Nikolaos, Crete, Greece.