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Review Article

The Techniques of Cultural Heritage: Literature Review

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Abstract

Documentation of cultural heritage is basically a computerized or digital representation of objects contains the realistic portrayal of objects in 2.5 or 3D and other details. It is an unquestionable reality that the most vital thing for transmitting cultural heritage to posterity is a delicate documentation. Up to the present there have been numerous advancements in documentation of cultural heritage through technology development, and contemporary documentation techniques have progressed speedily. In time, current techniques have turned out to be desirable over conventional methods in engineering in the existent state and in assurance of disfigurements and preparation of measured drawing projects of historical edifices. Over the most recent ten years, direct 3D documentation techniques are very well known and that great advancement**.** Generally several main geomatics approaches are using for documentation , in first approach, image based such as close range photogrammetry, unmanned aerial vehicles, infrared (IR) images, second approach are non-image-based such as conventional measurements, terrestrial laser scanning, and In third approach, many researcher are using hybrid method that companied between different techniques. With ongoing improvements in PC and information technologies, this notable customary method has been change with digital close-range photogrammetry. This new technique offers us new open doors, for example, automatic orientation and procedure of the measurement, create of 3D vector information, advanced ortho-image and digital surface model. Laser scanning is another innovation that lately has turned out to be progressively well known for documentation which gives exceptionally thick 3D points on an object surface with high exactness. Also, the 3D model and ortho-photo can be effortlessly created utilizing produced 3D point clouds and recorded digital pictures. This paper gives an overview about the techniques related with documentation of cultural heritage and the uses of cultural heritage.

Keywords: Cultural heritage; Documentation; Digital photogrammetry; Close range photogrammetry; unmanned aerial vehicles.

1- INTRODUCTION

Cultural heritage and architectural sites are of the most valued possessions hereditary from our antecedents. Transporting them to future generations should be the goal of every mindful man, as they represent our identity. Human or natural effects vanishing these objects of cultural heritage, therefore it is essential to document them to preserve this valuable culture to the next generations. Documentation and conservation process enables saving and rebuilding of the object if it is damaged, and also checking, studying and recognizing variations in the objects [1]. As the obtainability of resources for maintenance and rebuilding is limited, the digital documentation of heritage sites and observing of deformations caused by the environment are progressively significant for cultural heritage conservation [1, 2]. This chapter is reviewing and discussing methods available to document cultural heritage and architectural sites following different techniques and using different platforms. The chapter is also representing a theoretical background about digital documentation and 3D modeling and printing from close-range photogrammetry (CRP) which is the main focus of this research.

On the other hand cultural heritage and valuable architectural buildings and monuments are under a continuing danger of damage or even loss. The inclusive and precise recording is essential to reduce the danger of losing heritage. Cost-effective and easy to usage procedures are required to record this heritage. Photogrammetry has distinguished as an effective and powerful technique in this area, in addition to many other latest techniques[3].

As the recording system is a preferable to be based on low cost sensors than high cost ones, easy to use components, fewer efforts, and handy, but keeping accuracy as a priority factor, it is thought to be appropriate for non-expert users[4]. In recent years, due to the small size and low cost of the smartphones (mobile phones), it has been possible to improve the participation of lay people in heritage documenting process[5]. Documenting, recording, and managing cultural information, should not be an essential part of every maintenance project, but also conveying knowledge about heritage sites to future generations should be a priority as well [6]. Nowadays world's architectural and cultural heritage is losing quicker than it can be documented [7]. Man-made and the Natural catastrophes, like war, negligence, unsuitable conservation and uncontrolled expansion, are the main reasons that make the heritage disappear. Architectural and cultural heritage should preserve as possible, however, it is impossible to protect everything. One of the choices accessible to managers of the heritage and decision makers is to document this heritage before it lost [8]. Currently, documentation of digital cultural heritage in 3D form is a theme to study and applied [9]. The technique that used to create 3D models from image-based methodologies, designing the camera network is considered to be the fundamental step in its practical workflow [10]. This task is essential in practical applications due to its requirements for a detailed planning and a confident level of practical knowledge and experience. It is wrong to think that the optimum camera network must be planned in the field, and thus dispensing the preprocessing and planning [11]. There are several technique for documentation such as laser scanner, photogrammetry or by hybrid methods. On the other hand, there are different applications of documentation such as medical, industrial, traffic accident in addition to cultural heritage and architectural monument, which are the main interest in this research and thus will be discussed in details in the following sections.

2- Geomatics technique for cultural heritage documentation

These documentation techniques are mainly categorized in to the following approaches:

1- Image-Based

A- Documentation Using Photogrammetry

1- Close range photogrammetry.
2- Unmanned aerial vehicles.
3- Panorama.

B- IR Camera

2.1 Technique Based Documentation Methods

Documentation and 3D modeling of the built environment is a big challenge. It can be classified based on the technique used to build up the 3D model throughout the 3D documentation process adopted. A number of techniques and technologies are now in use such as the using of UAVs or by using laser scanners or photogrammetry or by using hybrid techniques as detailed below.

2.1.1. Image-Based

2.1.1. A Documentation Using Photogrammetry

Photogrammetry is an important method to document and conserve the archaeological sites and objects. This technology is stated on at least two photos with overlapping area to create the triangulation principles. Nowadays, CRP represents the fundamental factor of monument documentation process. The objective of CRP is to render the procedure of acquisition and processing of information faster and easier. This approach has a high accuracy with regard to texture and color, and giving 3D data of large sites in relative to conventional survey and in short time. Additionally, it is a safe technique due to non-contact, not intrusive character, and furnishes a large number of geometric and radiometric data. However, this technique has some limitation such as: complicated to use by non-proficient user, shadow usually causes to minimize the level of accuracy, final accuracy of data is related to the resolution and accuracy of the used camera, and many others.

2.1.1. A.1 Close Range Photogrammetry

Photogrammetry is an independent method in the documentation process. This method is based on at least two images with overlapped data, which guarantee the triangulation process. The aim of digital closerange photogrammetry is making the process of recording and processing data simpler and faster. This method is an accurate technique for documenting color and texture, and providing data of objects with different size and complexity in a relatively short time. This technique can be used when the access to the object is limited, or when the direct measuring on the object would threaten it. Today, using of-the-shelf cameras with high accuracy has made the close-range photogrammetric process much easier and more cost-effective to apply. Close-range photogrammetry has also a high applicability in generating 3D models of the targeted objects. These models can be useful in creating a 3D archive and answering to different aims of documentation. In short, Productions of photogrammetry can be rectified photos, orthophotos, and 3D models. Although the usability of photogrammetry can be classified according to the required accuracy and detail, generally, its application in archeology and heritage conservation can be enumerated as follows:

- Documentation of historic buildings and small artifacts, measuring the facades Providing color and texture data

- Measuring the deformation of buildings, analyzing the changes, and predicting the future changes, for example cracks and fissures. For this, a cloud point model of the object should be generated in different periods of time in order to be able to perform a continuous comparison between models and analyses the changes.
- Surveying the excavation sites
- 3D modeling of historic cities
- Reconstruction of destroyed objects
- Creating an accurate metric archive for analysis and future needs

One of the essential and reliable techniques in documenting monuments and cultural heritage is digital CRP [12]. Lots of studies have been presented in this regard and demonstrated the power of CRP in cultural heritage documentation[13] for example, assesses the advantages of digital CRP in the construction of 3D models following robust technical process. The method of producing 3D models for documentation and conservation applications is divided into two steps. The first step is the photogrammetric recording in the required field. However, the second step represents the creation of detailed documentation data that describing the object geometry. The planned approach described in this paper is based on experiences gained from the preparation of technical documentation for objects of the historical towns of Karagoyevac (Serbia and Montenegro) and Banja Luka (Republika Srpska). Because cost is known to be one of the essential factors in documenting process, [14] discusses the using of precision digital cameras of mobile phones in CRP cultural heritage applications. The work is divided into two steps. The first step includes the determination of the camera accuracy to be used in this application. Two mobile phones were used: the first is Nokia 3650 and the second Nokia 7650 mobile phone. The results compared to accurate measurements obtained from non-metric digital camera Olympus model C-2/D- 230 for accuracy assessment. However, the second step is the technical analysis of the results delivered from the mobile phone camera in comparison with those delivered from the Olympus non-metric camera. The results showed that there is a promising good relative accuracy can obtain when using the mobile phone camera, which is sufficient for some applications. This study showed that the digital mobile phone camera is accurate enough to be used in some projects that do not require a high degree of accuracy. However, the relative accuracy of the mobile phones cameras was lower than the Olympus digital camera. The weakness of mobile phones accuracy may be due to the low accuracy of their images. On the other hand, the results delivered by[15] in a project presented to the Institution of Cartography and Photogrammetry at Warsaw University of Technology have shown new perspectives regarding the degree of details can deliver from digital cameras. The digital surface model (DSM) and the shapes of the three different kinds of objects with various shapes, size and texture, deals with archaeology, architecture and medicine applications were determined. The typical amateur digital cameras and more projection automatic system were used for the acquiring of the data. The chief principles of data gaining and processing, in addition to the results and 3D modeling accuracy of the selected objects were presented. Figure (1) shows the 3D model of a section of one of the selected buildings in this study. The accessible amateur digital cameras make CRP technique more general and economical to obtain the required accuracy. The differences in the mean square errors assessed on base of 56 control points were within 0.2 - 0.3 pixels.

Fig-1: 3D model with the textural data from 3D documentation project using CRP [1].

Further, in this respect, reference [16] analyzed error propagation rules in the 3D reconstruction routine and study the impact of factors related with the results of the 3D reconstructed model. They give an answer about the level of accuracy that can reached without any manual operation and any control points, using the single digital camera. The selection of the optimal digital camera with high capabilities and thus select the optimal number of images for processing is also very important. The researcher concluded that it is feasible to use the automatic 3D reconstruction in CRP, but for very accurate applications e.g. with an error around 0.5mm. In this respect, reference [17] represents a paper discussing caravansaries 3D documentation which is representing one of the essential cultural heritages in the world. Caravansary refers to the home or the sanctuary for caravans. In this study, the ancient caravansary was documented and evaluated by digital photography using the CRP technique as shown in Figure (2). It showed that the utilization of this method was exceptionally effective compared to the conventional method of documenting cultural heritage. The RMSEs values obtained by photogrammetric adjustment were 2.2 mm, 2.1 mm, and 3.6 mm in X, Y, and Z respectively.

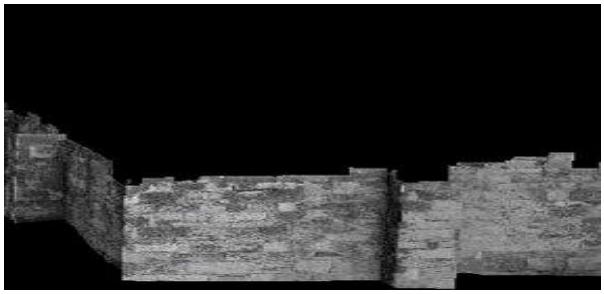

Fig-2: 3D visualization with covered photo texture of east side of caravansaries in Turkey[2].

Documentation not only enables the construction of planning base of the rebuilding if there are damages of any piece of the object, but also checkup, analysis and finding variations in the object [18]. Therefore, it is necessary for documentation these heritage and architecture objects by using modern technologies. Further [1], presented the photogrammetric procedures used to make measurements of the Emir Ishak Bey Tomb as shown in Figure (3). This tomb is situated in the Public Garden and in the north of Serafettin Mosque. At the beginning, photogrammetric control points must be measured by a total station to prepare for the documentation project, and to form the 3D point data. The photos of the tomb were taken using a digital camera SonyY DSC-W50 with 6 MP. These control points together with the digital images are utilized to generate the 3D model of the tomb by the PhotoModeler software. Using 17 GCPs, the error achieved was 1.1 mm, 1.0 mm and 0.9 mm. in X, Y, and Z respectively.

Fig-3: Emir Đshak Pasha Tomb [1].

2.1.1.A.2 Unmanned Aerial Vehicles

The using of Unmanned Aerial Vehicles (UAV) for documentation purposes as shown in Figure (4). becomes a common choice due to the reliability and ease of use, so it is possible to have high-resolution images of sites and objects from above [19]. UAV or Unmanned Aerial Vehicle as it can be understood form its name operates without an on-board pilot [21]. Other terms such as Remotely Piloted Vehicle (RPV), Remotely Operated Aircraft (ROA) Remote Controlled Helicopter (RC-Helicopter), Unmanned Vehicle Systems (UVS) and model helicopter [21]. Are also used for this system. [22] Different types of UAV are categorized to their weight, size, endurance, flying attitude. This system is composed of a light low-cost aerial vehicle such as a small helicopter, a digital camera, and GNSS/INS systems for identifying the position and navigating the system. The initial motivation for developing UAV systems was for military purposes. However, in the recent years, the application of UAV has expanded considerably so that it is used for documentation and surveying purposes. This low-cost system can be an approperiate alternative to the classical manned aerial photogrammetry [21]. This method has indeed proved its efficacy in the of cultural heritage and archaeological sites. Documentation and 3D modeling and surveying of historic sites and structures can be performed using low-altitude flight. Using UAVs, we are able to produce panoramic images, Digital Surface Model (DSM), ortho-photo, and three-dimensional models with high accuracy of the surveyed objects. Some advantages of this non-intrusive system are:

- Real-time capability [22], fast image acquisition, and short interruption times which make it suitable for archaeological field-work [23].
- Small areas can easily be covered by this system so that images from different sides of the targeted object can be provided [24].
- UAVs provide the opportunity to survey inaccessible and/or dangerous areas which cannot be accessed directly using other systems or piloted aerial systems [25]. In contrast, vibration due to their relatively low weight and the impact of wind, the maximum load they can carry and the integration of different sensors are some of the problems we are dealing with in UAVs.

Fig-4: 3D model of Asinou Church [20].

2.1.1.A. 2 Panorama

Panorama photography multi-image photogrammetric methods. This method is a an excellent example of rendering based on image in contrast to rendering based on model, which overcomes the problems of 3d modeling. Panorama images are useful for measuring. Moreover, these images can be used for analyzing the dimensions if adjustment and camera calibration is operated properly. Nowadays, panoramic cameras have increased the reliability of this method, and removed the problems relating to the

stitching and overlapping process of images. Panoramic photography can be used in documentation as shown in figure (5), education, tourism, and presenting the historic buildings and sites. The most important advantage of this method is its capability in storing the data of a large object with the help of low number of pictures. Low cost, less time, ease of use in geographical information systems, the ability of presentation in web pages, high attraction for users are among the other advantages of this method. On the contrary, large image size which needs large memory, the need for viewer softwares, the limitation for movement in the interior spaces, limitation in the camera angle are some the disadvantages of this technique.

Fig-5: 3D documentation project using panorama photogrammetric

2.1.1.B. Documentation Using Infrared (IR) Images

IR is the part of the electromagnetic spectrum that we perceive as heat. Thermal or infrared energy is not visible to the naked eyes because its wavelength is too long to be detected by the human eye. In the spectrum of electromagnetic waves, we generally work with visible light. Standard CCD/ CMOS cameras for example, are sensitive to visible light spectrum. However, nowadays with the help of advanced technologies, we are able to acquire data in ultraviolet (UV), and infrared (IR) portion of the electromagnetic spectrum. Everything with a temperature above absolute zero emits heat. In thermography or infrared light, an infrared imaging and measurement camera is used to observe and measure the emitted thermal energy from a target. This capability can be highly useful in the documentation of cultural heritage and studying the art work [26] for deeper analysis [27] particularly for monitoring and conservation of historic monuments [28]. These cameras are able to show thermal distribution of the surface in an image. Some physical conditions such as relative humidity, atmospheric temperature, reflected apparent temperature and material properties of an object like the degree of emissivity affect this distribution [29]. Modern IR imagers are highly sensitive temperature differences of 0.1ºC or less, which enables them to evaluate and present subtle thermal phenomena, in the form of slight temperature gradients. IR camera provides the capability of observing and documenting back structure of frescoes and paintings, padding, older layers, hidden structures, pentimento and preparatory drawing. It also helps analyse the composition of objects and buildings, and the state of conservation of façades, vaults and architectural structures [27]. This nondestructive tool [30] can be used in detection of moisture and rising damp in buildings and masonry structures, identification of cracks. IR images can also be integrated with and mapped on digital images and 3D models. With this capability a quantitative analysis of damages is possible as we access to the metric data.

4-CONCLUSTION

Cultural heritage protection is a key matter today worldwide. There has been an increase openly mindfulness over late years that these sorts of landmarks constitute an imperative piece of our past. In this work we have shown the techniques and applications for the documentation. Cultural heritage preservation is a key issue today worldwide. There has been an increase in explicit awareness in recent years that these types of monuments are part of our past. In this work we have shown the techniques and applications for the documentation. An overview of the theoretical background and methodologies in procedures of documentation utilizing Image-Based techniques are presented. The most appropriate approach for documentation procedures from the data obtaining to the last product utilizing monoscopic multi-image evaluation, stereo digital photogrammetry is investigated. In some country like Iraq, where aerial flight is restricted for mapping and modeling purpose. So in these cases: Close range photogrammetric method is most effective solution to documentation. It gives better outcome and good accuracy.

Therefore, the automated methods are preferred instead of the manual ones. Conclusion of this research paper is that, So many researchers are working for documentation of cultural heritage, some are working for techniques and some of them are working for applications of documentation of cultural heritage. Research is going on continuously to achieve more and more accuracy in less time with low cost of project, so this documentation can be used for various engineering and non-engineering purposes.

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