Contemporary Digital Technologies at the Service of Cultural Heritage

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1 Introduction

Cultural heritage is recognized by all civilized countries of the world as the most important carrier of historical memory for mankind. However, it is nor respected and protected as it should be in all cases. Hence, cultural heritage is in great danger as it may be destroyed, lost, altered, forgotten for a number of reasons. The main sources of danger are natural hazards, violent actions, such as wars, terrorism, etc., looting, illicit trafficking, vandalism, modern construction activities, globalization, modern way of life and indifference, urban population growth and many more. In Fig. 1, some examples of such destructions are depicted.

Consequently, their thorough study, preservation and protection are an obligation of our era to mankind's past and future. Respect towards cultural heritage has its roots already in the era of the Renaissance. During the nineteenth century, archaeological excavations became common practice, while they matured in the twentieth century. Over the recent decades, international bodies and agencies have passed resolutions concerning the obligation for protection, conservation and restoration of monuments. The Athens Convention (1931), The Hague Agreement (1954), the Chart of Venice (1964) and the Granada Agreement (1985) are some of these resolutions in which the need for the full documentation of the monuments is also stressed, as part of their protection, study and conservation. Nowadays, all countries of the civilized world are using all their scientific and technological efforts towards protecting and conserving the monuments within or even outside their borders assisting other countries. These general tasks include geometric recording, risk assessment, monitoring, restoring, reconstructing and managing cultural heritage. Indeed, it was in the Venice Charter (1964) that the necessity of the geometric documentation of cultural heritage was

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Fig. 1 Destruction of cultural heritage (natural hazards, looting and violent actions)

first set as a prerequisite. In Article 16 it is stated '… *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…*'.

1.1 Interdisciplinary Cooperation

Traditionally, scientists specialized in monument maintenance were also responsible for their geometric documentation. These experts mainly belonged to the field of archaeology and architecture. However, over the past decades more and different specialists developed an interest in the monuments, as they proved definitely able to contribute to their study, maintenance and care [4]. Among them are surveyors, photogrammetrists and geomatics engineers in general, as the technological advances have enabled them to produce interesting, alternative and accurate geometric documentation products. Until the end of the nineteenth century, architectural heritage had been a matter of national concern only and most of the laws regarding the protection of historic buildings, in Europe at least, date back to that period. Countless associations existed in each country, but their scope never went beyond national borders. Cultural internationalism, as we know it today, was an outcome of the First World War, with the creation of the League of Nations, and most of all of the Second World War, with the creation of the United Nations Organisation and the establishment of the UNESCO. The Athens Conference (1931) on restoration of historic buildings was organized by the International Museums Office, and the Athens Charter, drafted

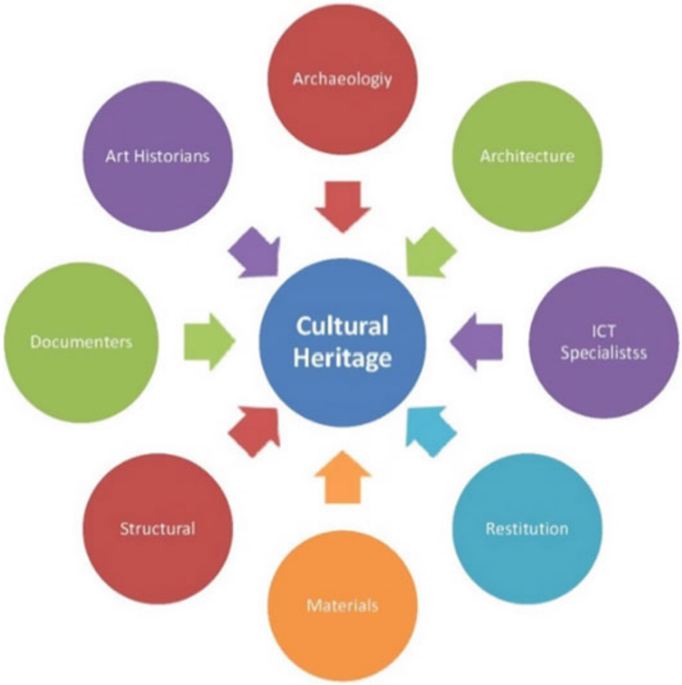

Fig. 2 The interdisciplinary contribution to cultural heritage

by Le Corbusier at the fourth Assembly of the International Congresses on Modern Architecture (1933) was published anonymously in Paris in 1941 both represent a major step in the evolution of ideas because they reflect a growing consciousness among specialists all over the world, introducing for the first time in history the concept of international heritage.

Today, this way of thinking is slowly changing and the traditionally involved scientists, like archaeologists and architects, tend to accept and recognize the contribution of other disciplines to the agenda of cultural heritage. Hence, it is rapidly becoming an interdisciplinary and intercultural issue (Fig. 2) [4].

UNESCO (1946) and the Council of Europe have formed specialized organizations for taking care of mankind's cultural heritage. ICOMOS (International Council for Monuments and Sites) is the most important one, but also CIPA Heritage Documentation (International Committee for Architectural Photogrammetry), ISPRS (International Society for Photogrammetry & Remote Sensing), ICOM (International Council for Museums), ICCROM (International Centre for the Conservation and Restoration of Monuments) and UIA (International Union of Architects) are all involved in this task (Fig. 3). The Venice Charter was conceived from the necessity to form a union of specialists of conservation and restoration independent of the already existing associations of museologists, ICOM. In 1957, in Paris, the First Congress

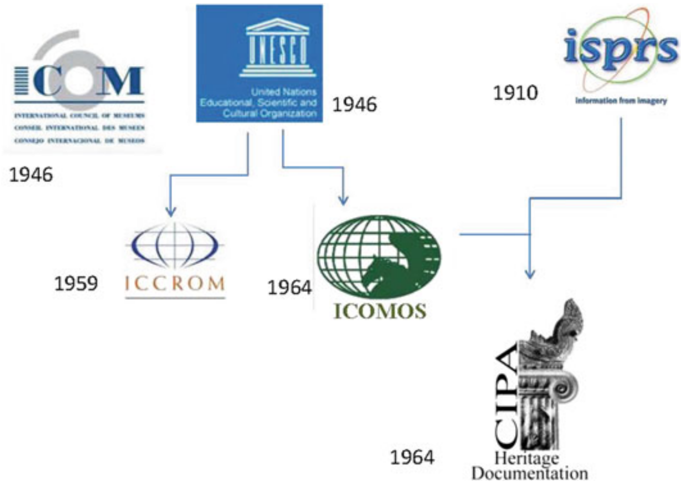

Fig. 3 International organizations involved in cultural heritage

of Architects and Specialists of Historic Buildings recommended that the countries which still lack a central organization for the protection of historic buildings provide for the establishment of such an authority and, in the name of UNESCO, that all member states of UNESCO join the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) based in Rome [4].

ICCROM is an intergovernmental organization dedicated to the conservation of cultural heritage. Its members are individual states which have declared their adhesion to it. It exists to serve the international community as represented by its Member States, which currently number 133. It is the only institution of its kind with a worldwide mandate to promote the conservation of all types of cultural heritage, both movable and immovable. The decision to found the International Centre for the Study of the Preservation and Restoration of Cultural Property was made at the 9th UNESCO General Conference in New Delhi in 1956, at a time of mounting interest in the protection and preservation of cultural heritage. It was subsequently established in Rome in 1959 at the invitation of the Government of Italy. ICCROM aims at improving the quality of conservation practice as well as raising awareness about the importance of preserving cultural heritage. The Second Congress of Architects and Specialists of Historic Buildings, in Venice in 1964, adopted 13 resolutions, the first one being the International Restoration Charter, better known as Venice Charter, and the second one, put forward by UNESCO, provided for the creation of the International Council on Monuments and Sites (ICOMOS).

1.2 CIPA Heritage Documentation

CIPA Heritage Documentation was founded in 1964 as an International Scientific Committee (ISC) of ICOMOS and ISPRS (International Society for Photogrammetry and Remote Sensing) and hence is a dynamic international organization that has twin responsibilities: keeping up with technology and ensuring its usefulness for cultural heritage conservation, education and dissemination [4]. These two sometimes conflicting goals are accomplished in a variety of ways, through (cipa.icomos.org)

- Encouraging and promoting the development of principles and good practices for recording, documentation and information management of cultural heritage;
- Leading and participating in international training programs for conservation and informatics professionals, students and site personnel;
- Advising government bodies, regional authorities, nonprofit groups and institutions on tools, technology and methods for using technology;
- Sponsoring an international network of professionals in both the fields of technology and cultural heritage for scientific research but also applied practical experience;
- Providing a platform through the biannual International Conference for the exchange of ideas, best practices as well as scientific research papers.

In the recent past, CIPA undertook the RECORDIM initiative, recognizing that there are critical gaps in the fields of heritage recording, documentation and information management between those who provide information for conservation and those who use it, i.e. providers and users of contemporary documentation information. In response, the International Council on Monuments and Sites (ICOMOS), the Getty Conservation Institute (GCI) and CIPA together created the RecorDIM (for Heritage Recording, Documentation and Information Management) Initiative partnership [4]. The purpose of the initiative (started in 2002 and closed on 2007) was to bring information users and providers together to identify the nature of the gaps between them, to develop strategies to close the gaps and to recommend a framework for action.

The involvement of contemporary Digital Technologies (ICT) in the domain of cultural heritage has increased the gap between providers, i.e. those who master these techniques and are able to apply them and the users, i.e. those scholars traditionally concerned with the cultural heritage. This gap was caused mainly due to the mistrust of the latter towards contemporary technologies and lately ICT. However systematic efforts have been applied, like CIPA's RecorDIM (http://cipa.icomos.org/index.php?id=43) which have managed to narrow if not bridge this gap.

This current effort concerned with the 3D virtual reconstruction of monuments is motivated exactly by this endeavour to bridge this gap. This will only be done through a deep understanding of each other's needs and through the proper exploitation of ICT with the benefit of cultural heritage always in mind. In addition, the notion of virtual reconstruction is introduced and its use for bringing the reconstructed monuments into a museum environment is investigated [4].

This interdisciplinary approach to the issue of cultural heritage has opened vast new possibilities and led to new alternative products for the benefit of monuments. These new possibilities include, among others, the production of 3D models, virtual reconstructions, virtual restorations, monitoring of constructions and the applications of serious games for educational and dissemination purposes.

Digital surveying and geometric documentation of cultural heritage require the cooperation of several disciplines and expertise in order to produce results that sufficiently satisfy the highly demanding environment of conservation, restoration, research and dissemination. It should not escape our attention that resources are frequently inadequate while the infrastructure used (equipment, hardware and software) is expected to achieve the maximum possible benefit.

2 Digitization of Cultural Heritage

Nowadays, the rapid advances in digital technology also referred to as Information Communication Technologies (ICT) have provided scientists with new powerful tools. We are now able to acquire, store, process, manage and present any kind of information in digital form [4]. This may be done faster, more completely and it may ensure that this information may be easily available for a larger base of interested individuals. Those digital tools include instrumentation for data acquisition, such as scanners, digital cameras, digital total stations etc., software for processing and managing the collected data and of course computer hardware, for running the software, storing the data and presenting them in various forms.

The introduction of digital technologies has already altered the way we perceive fundamental notions like *indigenous, artefact, heritage, 3D space, ecology*, etc. At the same time, they tend to transform the traditional work of archaeologists and museums as they are so far known. In other words, DT redefines the relationship to CH, as they enable universal access to it and they also connect cultural institutions to new ‘audiences’. Finally, they appeal to new generations, as the latter is, by default, computer literate. In this way, we experience a ‘democratization’ of cultural information across geographic, religious, cultural and scientific borders [4]. Cultural heritage is nowadays, an international, interdisciplinary and intercultural responsibility.

The introduction of digital technologies may contribute to all traditional steps of archaeological practice. It goes without saying that the degree of contribution of ICT is different in the various stages and in the various cases. Modern technologies of remote sensing and archaeological prospection assist the touchless and rapid detection of objects of interest. Spectroradiometers or ground penetrating radars or even the simple processing of multispectral satellite images may easily lead to the rapid location of underground or submerged objects of interest. Contemporary noncontact survey technologies, such as photogrammetry, terrestrial laser scanning and digital imaging, may be used to produce accurate base maps for further study, or 3D virtual renderings and visualizations. The collected data may be stored in interactive databases, georeferenced or not, and be managed according to the needs of the experts. Finally, ICT may assist in the presentation stage, by producing virtual models, which may be displayed in museums or be included in an educational gamification, or serve purposes of enabling handicapped persons to admire the treasures of the World's cultural heritage [4].

The use of digital technologies in preservation and curation in general of cultural heritage is also mandated by UNESCO. With the *Charter on the Preservation of the Digital Cultural Heritage* [25], this global organization proclaims the basic principles of digital cultural heritage for all civilized countries of the world. At the same time, numerous international efforts are underway with the scope to digitize all aspects of cultural heritage, be it large monuments, or tangible artefacts or even intangible articles of the world's legacy.

The impact of digital technologies on the domain of cultural heritage has increased the speed and automation of the procedures which involve processing of the digital data and presentation of the results. At the same time, accuracy and reliability have been substantially enhanced. However, most important is the ability to provide to the users new and alternative products, which include two-dimensional and three-dimensional products, such as orthophotos and 3D models. 3D modelling, on the other hand, is the process of virtually constructing the three-dimensional representation of an object. The use of 3D models is highly increased nowadays in many aspects of everyday life (cinema, advertisements, games, museums, medicine, etc.). All in all, the digitization of the world's cultural heritage whether it is tangible or intangible is now possible.

3 ICT at the Service of CH

The integrated documentation of monuments includes the acquisition of all possible data concerning the monument and which may contribute to its safeguarding in the future. Such data may include historical, archaeological, architectural information, but also administrative data, past drawings, sketches, photos, etc. [4]. Moreover, these data also include metric information which defines the size, the form and the location of the monument in 3D space and which document the monument geometrically. The geometric documentation of a monument, which should be considered as an integral part of the greater action, the integrated documentation of cultural heritage may be defined as [24]:

- The action of acquiring, processing, presenting and recording the necessary data for the determination of the position and the actual existing form, shape and size of a monument in the three-dimensional space at a particular given moment in time.
- The geometric documentation records the present of the monuments, as this has been shaped in the course of time and is the necessary background for the studies of their past, as well as the care of their future.

For the geometric recording, several recording methods may be applied, ranging from the conventional simple topometric methods, for partially or totally uncontrolled surveys, to the elaborated contemporary surveying and photogrammetric ones, for completely controlled surveys. The simple topometric methods are applied only when the small dimensions and simplicity of the monument may allow it when an uncontrolled survey is adequate, or in cases when a small completion of the fully controlled methods is required. Surveying and photogrammetric methods are based on direct measurements of lengths and angles, either on the monument or on images thereof. They indirectly determine three-dimensional point coordinates in a common reference system and ensure uniform and specified accuracy. Moreover, they provide adaptability, flexibility, speed, security and efficiency. All in all, they present undisputed financial merits, in the sense that they are the only methods, which may surely meet any requirements with the least possible total cost and the biggest total profit. To this measurement, group belong complicated surveying methods with total stations, 3D image based photogrammetric surveys and terrestrial laser scanners (TLS). All these methods manage to collect a huge number of points in 3D space, usually called point cloud, in a very limited time frame.

All these techniques can be categorized in different ways. The experience shows that the most efficient method is to characterize them by the scale at which they can be used as well as by the number of measurements they can be used during data acquisition. Practically, this means that they are related to the object size as well as to the complexity of the object. Böhler and Heinz (1999) proposed and developed a system to summarize all existing techniques in terms of scale and object complexity. This is adapted to include modern technologies and is shown in Fig. 4 [21].

According to this figure, the metric surveying techniques are organized considering the scale of the outcome which is a function of the object size and the representation based on the required details. The complexity of the survey can be conveyed by the number of recorded points. In practice, this ranges from one single point describing the geographic location of a single cultural heritage object, to some thousands of points (e.g. a single CAD drawing of a simple monument) or to a few millions of points (e.g. a point cloud) for the detailed representation of a cultural heritage site.

Recording techniques are based on devices and sensors which perform the necessary measurements either directly on the object, or indirectly by recording energy reflected from the object. In the latter category, one may broadly distinguish between active and passive sensors. Active sensors send their own radiation to the object and record the reflectance, while passive ones rely on the radiation sent to the object from some other source. Usually, the latter are image-based sensors, which record the visible light reflected from the objects of interest.

The terrestrial image-based survey comprises all those methods, techniques and technologies that are using images in order to extract metric and thematic information from the object imaged. Within this section, the most important image-based digital technologies supporting the digital surveying and documentation of cultural heritage will be discussed and presented. The main concern will be given to digital cameras and sensors, especially the new entries, the contribution of the Unmanned Air Vehicle

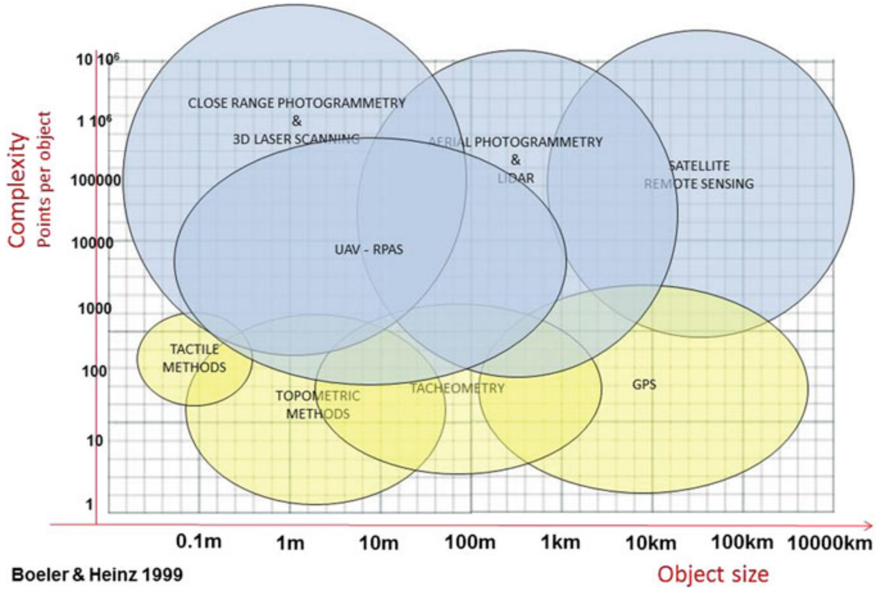

Fig. 4 Three-dimensional survey techniques characterized by scale and object size and complexity

(UAV) or Remotely Piloted Aircraft Systems (RPAS) or Unmanned Aerial Systems (UAS), but also the useful role that Image Assisted Total Station (IATS) technologies are playing in the recording, monitoring and documentation of cultural heritage.

4 Selected Examples

In order to illustrate the above, some representative examples of cultural heritage digitization will be presented They include (1) the successful attempt to digitize a collapsed traditional stone bridge for assisting the restoration study, (2) the complete geometric documentation of a prominent Athens monument based entirely on image-based techniques and (3) the implementation of an HBIM system for cultural heritage.

4.1 The Restoration of a Collapsed Bridge[1]

A variety of arched stone bridges exist in the Balkan area, built mainly in the eighteenth and nineteenth centuries or even earlier. Just in the Epirus region in northwestern Greece, there are more than 250 magnificent examples of such historic structures

[1] Adapted from [5].

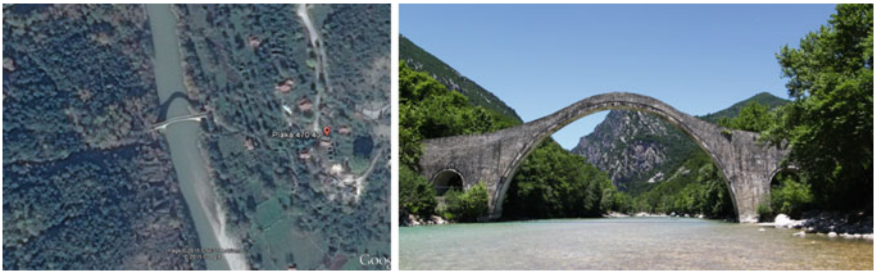

Fig. 5 The Plaka Stone Bridge

spanning over the rivers and streams and bridging them with one to four arches. Such structures were built for pedestrian and animal passage, as the rivers did not allow easy crossing, especially during winter [12].

The stone bridge of Plaka over river Arachthos (Fig. 5) was a representative example of the aforementioned monuments. It was built in 1866 by local Greek stonemasons in order to facilitate transportation and trade needs (http://www.petrinagefiria.uoi.gr/). It was the widest stone bridge in the area of Epirus with 40 m span and the biggest single-arch bridge in the Balkans with a height of 20 m (Fig. 5). Next, to the main arch, there were two smaller ones 6 m wide, the so-called relief arches [20].

Apart from its significant size and age, the stone bridge of Plaka was a renowned stone bridge in Greece because of its emblematic historic meaning. First, it was the border between free Greece and the occupied part of Greece by the Ottoman Empire between 1881 and 1912. During World War II, the bridge was bombed by the German army with partial damages. At the same period, representatives of the various armed groups of Greek Resistance signed the Treaty of Plaka on this very bridge.

Before the implementation of any actions, a thorough geometric documentation is necessary, as clearly dictated by the Venice Charter (1964). For that purpose, the Laboratory of Photogrammetry undertook two tasks (a) to produce digital three-dimensional drawings from a documentation study conducted in 1984 using traditional surveying techniques [9] and (b) to produce a textured three-dimensional model of the Plaka Stone Bridge in order to geometrically document its shape and size before the collapse. This 3D model would be produced from existing images taken by visitors of the bridge over the years. These documentation products will form the basis for any eventual reconstruction study [20] (Fig. 6).

Common image-based 3D modelling of the current state of a monument requires data acquisition in the field. Surveying, photogrammetry and laser scanning techniques can be combined to produce a full and accurate 3D model of the object. Such approaches cannot be applied in cases of sudden loss of cultural heritage objects due to a number of reasons such as fire, earthquakes, floods, looting, armed conflict, terrorism, attacks, etc.

Fig. 6 The remains of the bridge after destruction (http://epirusgate.blogspot.gr/2015/02/blog-post_32.html)

Modern photogrammetry and computer vision techniques manage to create useful and accurate 3D models of objects of almost any size and shape, by combining robust algorithms and powerful computers. Multiple images depicting the object from different viewpoints are needed and the so-called SfM and MVS procedures are implemented. These images do not necessarily need to have been captured by calibrated cameras, though. Compact or even mobile phone cameras can also be used. Moreover, capturing geometry is nowadays flexible, in contrast with the traditional strict stereo-normal case of the past. A variety of recent studies are examining the creation of 3D models of cultural heritage objects and sites with the use of SfM algorithms [1, 10, 17, 18]. The lack of images or other surveying data in lost cultural heritage objects has led to the use of random, unordered images acquired from the web. However, few projects, many of them EU funded, make use of data available on the web for such a purpose. Some recent studies are dealing with the 4D (space-time) virtual reconstruction of cultural heritage objects using web-retrieved images [11, 14, 19]. An approach for diachronic virtual reconstruction of lost heritage based on historical information integrated with real metric data of the remains was proposed by Guidi and Russo [7].

For image-based virtual reconstruction, many images from different points of view are required. As already implemented in similar cases in the past, the contribution of people that have visited the area for tourism or other reasons and have taken pictures was sought. Crowdsourcing has already been used for applications in the cultural heritage domain [16]. However, none of the similar actions produced a metric product like the present one.

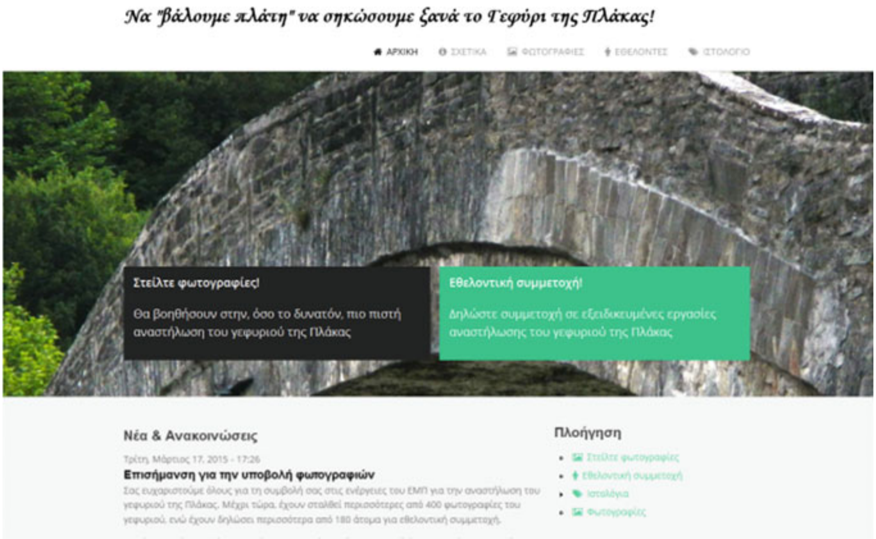

Fig. 7 Homepage of the crowdsourcing webpage

The key aspects of a project like the present one, concerning crowdsourcing information can be summarized as follows:

- The project has a time limit.
- The contribution of the users is of one type of content, i.e. images or video sequences.
- Special information (metadata) about the viewpoint of the images, the equipment used or the time taken could be useful.

To provide a suitable framework for the above, a website has been developed using the Drupal CMS (Fig. 7). Drupal is a Content Management System (CMS) with proper functions for community websites and has been used for educational and research crowdsourcing purposes [8, 15]. More specifically, the website developed includes five sections: (a) a news and announcements page, (b) a general info page, (c) a submit content (images) page, (d) a submit page for volunteers and (e) a blog page. To collect the images, the 'submit images' page is the only section utilized, since it also provides the required information to the contributors [20].

Within the first month of its operation, the website has been visited around 2800 times. More than 470 images were uploaded to the platform during these sessions by more than 130 contributors. Apart from the uploaded content, approximately 200 images and 15 videos were collected through other means, mainly by ordinary mail delivery, by contacting the contributors.

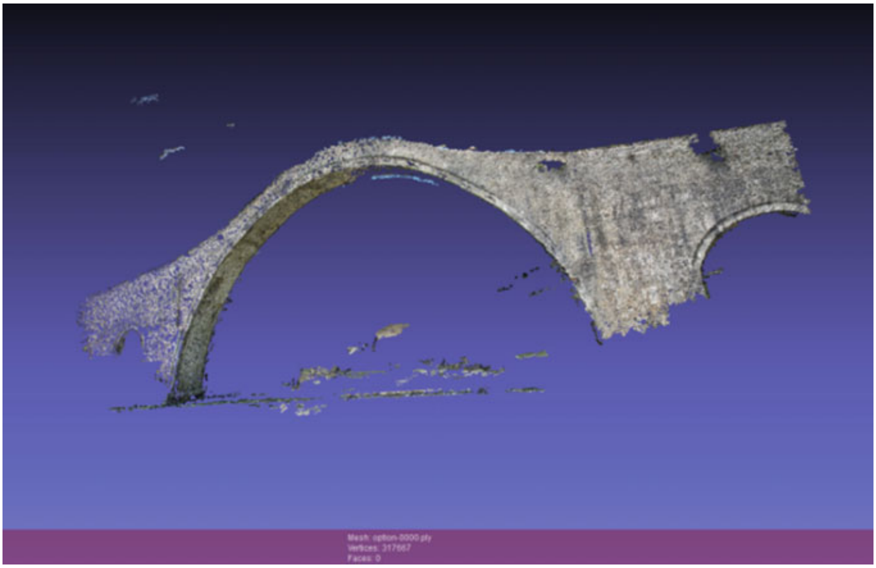

Fig. 8 Dense point cloud after PMVS software (VisualSfM)—51 images

The majority of the collected images were of high resolution, correctly focused and without significant perspective or optical distortions. However, we had to cope with some special challenges in order to exploit as much as possible the rest of the images, which had many different problems. In addition, the majority of the collected photos were taken facing upstream and mainly from the east riverside due to landscape inaccessibility. This causes gaps and difficulties for the algorithm to converge to a stable geometry. After a thorough and careful sorting, it was established that less than 60 images fulfil the needs of the project in terms of viewpoint, image resolution, lighting conditions, occlusions, etc., which corresponds to 10% of the total contributions [20].

The selected data have been processed using commercial as well as free software. VisualSfM is a free GUI application for 3D reconstruction that implements SfM and PMVS along with other tools [2, 3, 28–30]. In this case study, a dense point cloud was produced by 51 images (Fig. 8).

In order to improve the results, a masking procedure was applied to the images while processed in Agisoft PhotoScan. Therefore, background elements that are subjected to temporal changes and obstacles (people, trees, mountains, etc.) have been excluded from photo-alignment. This results in less noisy dense point clouds (Fig. 9). A mesh has also been created, followed by the texturing procedure (Fig. 10).

Fig. 9 Dense point cloud produced in Agisoft PhotoScan—56 images

Fig. 10 A view of the textured mesh created in Agisoft PhotoScan

The experts working for the restoration proposal needed also the documentation of the current situation. Hence during a campaign some months ago, data was collected for the creation of the 3D models of the remaining pedestals. They were imaged with a high-resolution DSLR and some Ground Control Points (GCP) were measured. Using again SfM/MVS software, the three-dimensional models were produced (Fig. 11) and served as a detailed geometric basis for the restoration proposal.

It should be stressed that the wide promotion of the 3 × 3 Rules proposed by CIPA [27] and revised in 2013, available at the relevant webpage (www.cipa.icomos.org) would ensure the existence of more useful images and related metadata for the Plaka Stone Bridge, as the public would be more aware of the eventual future significance of their souvenir images. This may be useful in the future for other monuments in similar situations [20].

Fig. 11 3D models of the remaining parts of the bridge

4.2 Virtual Restoration

The monument of Zalongon is situated on top of an 80 m high and steep cliff about 30 km north of Preveza. The sculpture is about 18 m long and 15 m high and is a composition of several female figures. Although fairly recent, the sculpture has suffered severely from frost and strong winds and tourists inscribing their names on the monument's surface. For its complete restoration, a detailed and accurate geometric documentation and a three-dimensional model of the construction were required. Given the size and complexity of the monument, contemporary digital techniques were employed for this purpose [26].

The most interesting product, possible only with the use of contemporary digital methods, was the 3D model. For the creation of the surface of the 3D model, all of the original scans were registered into a common reference system by applying a method that was specially developed. The creation of high resolution textured 3D models is undoubtedly a nontrivial task as it requires the application of advanced data acquisition and processing techniques, such as geodetic, photogrammetric, scanning, programming, surfacing, modelling, texturing and mosaicking [4].

For achieving restoration, the basic steps are: identifying the destroyed parts, interact with the 3D model and extract the geometry of the parts to be restored, insert them virtually into the 3D model and finally assess the result, before a final decision. In the present case, the main points of interest were, of course, the destroyed figureheads, but there were also many other damages to be restored (Fig. 12).

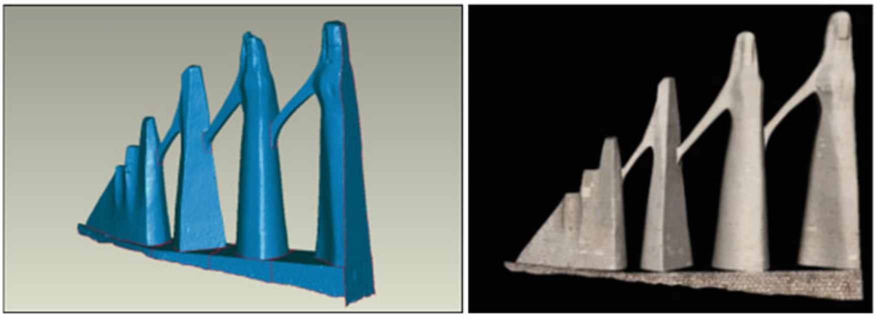

Fig. 12 Virtual restoration of the Zalongon monument

4.3 Virtual Museums

Developing and displaying a museum in a virtual environment has some advantages especially concerning the preservation and promotion of cultural heritage but also the development of tourism and the promotion of the touristic product. Virtual museums are important to both the visitors and the museums themselves and their curators. The majority of the museums only exhibit a small part of their collection due to the lack of space and of course due to the fact that some objects are extremely valuable or fragile [13]. In a virtual and interactive environment, the visitor is able to interact with the digitized exhibits and learn all the essential, historical information about them. Moreover, in a virtual environment, the visitor can view a virtual reconstruction of important objects, buildings and archaeological sites that may no longer exist are damaged or access to them is not permitted. Moreover, collections may also be displayed made of objects that are spread in various museums around the world [5].

The digitization of cultural heritage helps to preserve, store, renew, retrieve and make it accessible for a wider audience in a more appealing and contemporary way, especially to people with special abilities or people that may never have the chance to visit the real museum [23]. The wide use of Internet, social media and websites can make the digitized content of a museum more accessible and transport it to everyone all around the world. It is important to mention the result of Colorado University research according to which 70% of a total of 223 million people who visit a museum website would subsequently be more likely to go and also visit the real museum [6]. This means that the virtual museum functions in a complementary manner to the real museum. Finally, in virtual museum exhibitions, the visitor is able to fully control the navigation as well as to freely explore, move around, manipulate the exhibits and create his/her own, unique virtual experience or collection of 3D digital exhibits even from different museums. It is obvious that every effort and innovation that concerns the digitization of cultural heritage and the development of virtual museums and applications is a complicated, difficult, controversial task with many advantages and can only benefit and offer both the museums and the visitors. Especially in Greece, 65% of the tourists make an online search of their destination and 45% of them are interested in cultural heritage, monuments, museums and archaeological sites [5].

The Virtual Museum of the Stoa of Attalos is an application where the visitor is able to make a tour in the museum on his own, explore it, interact with the exhibits, rotate them and learn all the necessary information about them. The development of this application took into consideration various aspects such as the requirements' analysis, the architectural design, the planning of the exhibits' presentation, the user interaction, the programming process and the evaluation of the final product [13].

As far as the Virtual Museum of the Stoa of Attalos is concerned, the virtual environment hosts some of the exhibits which can be found on the ground floor of the Stoa of Attalos, in the Ancient Agora of Athens. For this project, 16 of the exhibits were chosen from the south part of the colonnade of the museum and the most important concern was to produce accurate, realistic and appealing 3D models that can be used in virtual applications, especially in a short period of time. That is why photogrammetric methods and 3D surveys were used for the mass production of the exhibits' 3D models and the development of the virtual museum. In order to process the data and build the accurate, textured 3D models of the exhibits PhotoScan Professional® v.1.1 software by Agisoft was used [5].

The application is available in Greek and English. In the beginning of the virtual tour, the visitor has the chance to read the instructions that are available in order to freely navigate in the environment and understand the options and opportunities he/she has in the virtual museum (Fig. 13). The parameters that concern the movement, speed, rotation, height vision and behaviour of the visitor were extremely important in order to make the navigation friendly and easy for the visitor, as the majority of them may not have any previous experience with this kind of applications or even with the use of computers [5].

Moreover, the ambience and the depth of field were properly adjusted in order to have a more clear and realistic view of the exhibits, which is also important to the visitor and his/her virtual experience in the museum. The visitor has the chance to learn and find out more information about the exhibits that attract and interest him/her simply by clicking on them (Fig. 14). Moreover, the visitor is able to rotate the exhibits while the panel with the information appears on the right part of the screen. In that way, the visitor is able to manipulate, closely examine and observe the details of every exhibit and at the same time learn not only the available information of the small panel that exists in the real museum, but also further information about it. The curator of the museum has the opportunity to choose the information that will be available to the visitor and this is one of the advantages of this kind of applications. Finally, the last element that was added in the virtual environment was a mini-map to help the visitor move around and navigate in the environment without feeling disorientated, simply by offering him/her a view of the virtual museum from the top [5].

Fig. 13 The environment of the virtual museum

Fig. 14 The virtual museum with all included elements

5 Concluding Remarks

With the presentation of a few characteristic implementation examples, it has been shown that digital contemporary technologies can contribute decisively to the conservation of cultural heritage. The final products are 3D models and virtual restorations or reconstructions of monuments that do not exist today or are at risk. Consequently, digital technologies and interdisciplinary synergies are of utmost importance. Equally important are the discussions and suggestions of scientists who have studied the monuments from a historical and archaeological point of view, proving once again that such interventions are a multidisciplinary process.

Virtual reconstructions, virtual restorations, monitoring and 3D models on the other hand support many other disciplines involved in cultural heritage. They help architects and structural engineers in their work for monuments especially in cases of restoration, anastylosis, etc. Archaeologists and conservationists have a very good tool at their disposal for their studies. Many applications can be generated from a virtual reconstruction like virtual video tours of the monument for educational and other purposes for use by schools, museums and other organizations, for incorporation into a geographical information system (GIS) for archaeological sites, for the design of virtual museums and the creation of numerous applications for mobile devices (e.g. mobile phones, tablets, etc.).

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