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REVIEW

From ground surveying to 3D laser scanner: A review of techniques used for spatial documentation of historic sites

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Abstract Modern technology has changed matters in documentation radically and promises to continue to bring rapid changes. Photographic and non-photographic (graphic) documentation tools are merging in one process, in which the digital photographic technology is the main base. 3D supports are still not popular among users involved in documentation of historic sites. Due to the digital technology, actually, there is an increasing gap between the specialized technician and non technician users. However, in order to build a bridge between the specialized technical and non technical users, a dialogue between them must now be created. They should not only discuss issues of data precision required and 3D accuracy standards, but simultaneously should discuss issues of achieving visualization production system, which can now be actually easily achieved by the modern digital photographic technology. This paper intends to present a review of the evaluation of historic sites documentation methods and survey techniques now available, focusing on the needs and requirements of the non-technical experts and users. It attempts to clarify some new aspects in documentation methods for the non-technical experts and users, and the impact of current technology in its quick development. This will be achieved through a comparative evaluation of the potentials of the application of digital methods in documentation, and in view of the main obtained quality, accuracy, time, costs and specific skills required. This evaluation covers traditional and pre electronic techniques to 3D laser scanning, which represents today the most advanced technology available for measuring and documenting objects, structures and landscapes.

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1. Introduction

Documentation is one of the principal ways available to give meaning, understanding, definition and recognition of the values of the cultural heritage. The importance of documentation may be undertaken as an aid to various treatment activities including; protection, restoration, conservation, preservation, identification, monitoring, interpretation, management of historic buildings and sites and cultural landscapes (Haddad and Akasheh, 2005; Haddad, 2007), in addition to creating a register of stolen movable objects. However, conservation and preservation of historic sites, research and application is increasingly aided by and dependent on digital media. Documentation tools have undergone a major transformation over the past 20 years, primarily due to the advent of the PC and advances in solid-state electronics. In fact, when dealing with documentation, it is important to represent materials, colors, decorations, physical and chemical decay and other phenomena.

The support of different specific skills is often required; hence it is crucial to choose the correct tools for a multidisciplinary analysis (Artesea et al., 2005). Meanwhile each documentation method has its own advantages and disadvantages, users that belong to the strict portrayal-school practically utilize the in-field hand measuring and tachometry methods. On the other hand, while 3D model is a correct and complete documentation of objects, 3D supports are still not popular among users in conservation and preservation; it is not an easy tool to deal with by an unskilled user. Due to the digital technology, actually, there is an increasing gap between the specialized technical and non technical users involved in documentation.

2. The non-technical experts/users and documentation techniques

Except for written documents, there are three techniques available of documentation. These are, non-photographic (graphic documentation; hand measuring and tachometry), photographic (photography, rectified photography, computer-rectified photography, photogrammetry and thermography) and 3D laser scanner. These documentation methods should be discussed and clarified before reviewing and understanding the impact of modern technology in the rapid evolution of these documentation methods.

2.1. Graphic techniques (non-photographic)

By hand measuring and tachometry as graphic methods, only the points seen as important for the description of the object are technically measured. The main applications of this method are in building survey and building analysis, complimentary and control measurements and in archaeological excavations. Hand measurement, in comparison with other methods, is favorable particularly in taking single measurements where visibility is limited. As a simple method and cheapen technique for small and non complex objects, with its immediate measurements, it can be set up quickly; meanwhile it develops the ability *in situ* observation.

However, it is time consuming, not accurate, an extensive way to create a map, with no coordinate reference as an analogue format. In fact, achieving accurate data for inaccessible locations with traditional survey techniques has always been a challenging task. Scaled drawings limit the extent to which very precise information can be recorded, displayed, and retrieved; the geometric recording of monuments at a large scale, i.e. larger than 1:100, presents several difficulties and peculiarities, which call for special attention by the user.

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 (Harrison, 2002). 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

Figure 1 (a) Camera stations to produce 3D model for the left gate of the stage of Jerash Southern Theatre in Jordan. (b) 3D model for the left gate. (c) Point determination from several photos to ensure that all points appear on three or more photographs from different angles with known focal length, using control points.

stations are different from most measuring systems used by archaeologists because they are effective over a great range of scales with accuracy that is unusual in our experience. However, archaeologists have probably been slow to use total stations, with notable exceptions, because of their cost and the complexity of their use and maintenance.

2.2. Photographic techniques

Photographs are easier to interpret and recognize than drawings; they contain information about surface detail and can provide information on the condition of a monument, before, during, and after restoration. This is difficult to achieve by the graphic documentation techniques. In the photographic methods, the entire vicinity is quasi completely determined, point by point, and the filtration for the extraction of the essential points happens later. However, shadow always causes errors in the results, because certain picture information is lost. The traditional analogue method of producing a rectified photography, when the surface of the object is completely flat, can provide immediate measurements for the first analysis. But as analogue format with no coordinate reference, it is time consuming and with non accurate data (Agosto et al., 2005b; Andrews et al., 2005).

Photogrammetry is a largely independent area used in documentation; it offers a rapid, accurate method of acquiring three-dimensional information, especially for large complex objects, while little field time is required, meanwhile photomodeler is a window software program that helps to extract accurate measurements and 3D models from photographs (Haddad and Akasheh, 2005; Haddad and Ishakat, 2007). It is based on using several photos from different angles with known focal length, using control points (Fig. 1). 3D laser scanner represents today the most advanced technology available for measuring and documenting objects. In contrast to photogrammetry, 3D scanners directly produce a huge number of 3D points, where 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 (Boehler et al., 2005; Lingua and Rinaudo, 2001; Kern, 2001; Haddad and Akasheh, 2005). Terrestrial scanners may be categorized into two groups: (1) triangulation scanners and (2) time of flight scanners (LIDAR). The triangulation method is most useful for smaller objects, while time-of-flight method is most useful for large objects. Today, laser scanners are widely used in the field of architectural, archaeological, and environmental surveying (Figs. 2–6). With its automated data capture capabilities, it is bringing new perspectives and can satisfy most requirements of those types of applications. This tool can be used standalone or in combination of other surveying techniques for multiple purposes (Rüther et al., 2003; English Heritage, 2007).

3. Evaluation of the impact of modern technology on documentation products

The method which should be applied in each case depends on various factors; cost and time, location facts, size extent of task (content as well as quantitative), accuracy class, non-destructive approach, and style of result presentation, interpretation and monitoring.

In practice however, the familiarity of the user or expert with one of the methods is often the deciding factor in which method is used, and not the optimal suitability of the method is often to the intended purpose. Taking into consideration that documentation frequently requires integrating data from different sources, the impact of the new technologies in historic sites documentation can be summarized as follows:

3.1. Data quality, flexibility and accuracy in graphic documentation techniques

It is of importance to highlight that technology alone has no place in determining the sought precision. It may provide limits, but the limits are now such that the scholars in charge need no longer ask for all the precision possible. In fact, the precision with which scholar measure and record has often been limited by the available technology and cost, but very high precision has been useless (Costantino, 2001). Whereas the problem was once measuring as precisely as possible or as precisely as a scaled drawing could display, the issue is now to measure and record as precisely as required for the particular project. Thanks to modern technology software, it can now be used with computer-supported hand measuring, as a mapping and coordinating aid on the basis of easier sketching.

wElectronic data collection with total station instruments permits the quick acquisition of large amounts of field data, together with the efficient and error-free transfer of the data to a computer. Once in the computer, the field data can be edited and analyzed for completeness of coverage and accuracy. Now, Total stations are becoming cheaper and easier to use, and offer a greater range of applications than they have had previously.

On the other hand, by the use of computer-aided design (CAD systems) software for documentation removes any impact of drawing scale on the process of measuring and recording. The limits on drawing precision that were once inherent in the use of scaled drawings have been removed by CAD systems (Costantino, 2001; Haddad, 2007). A CAD model can obviously calculate the distance between any two points with the same precision, which cannot be seen in a drawing of normal scale. Actually, all standard CAD systems maintain coordinates at levels of precision beyond the scholar's capacity.

With CAD program it is possible to document in 3D, and to record the information in segments that can be combined or separated, meanwhile many CAD software packages facilitate the visualization of CAD models, either as part of the CAD system. Thereby, documentation accompanying any CAD model should not only discuss issues of data precision and data density, but simultaneously should discuss the comparable issues of achieving visualization in combination with image determination, possibility of automated image rectification.

3.2. Data quality, flexibility and accuracy in photographic documentation techniques

As documentation tools are ''neutral'', and as users make the difference, digital photographic technology can play an optimistic role. In photographic documentation techniques a relevant difference arises in the acquisition process *in situ*, compared to a laboratory process. This concept is completely different from the graphic documentation process, where the *in situ* needs more time. With a realistic 3D model, its exploration could let the user obtain detailed data of various degrees, depending on the level of inquiry (Bornaz and Rinaudo, 2004; Artesea et al., 2005; Lerma et al., 2008); the more complex the structure, the more care and specialized data are necessary.

Analyzing the different documentation products and considering the documented object, the Orthophoto is sufficient as a support for a 2D drawing; a 2D representation can be obtained through the creation of the Orthophoto which is a useful and easier way of elaborating metrical data also by untrained users (Bornaz and Dequal, 2004; Andrews et al., 2005; Haddad and Ishakat, 2007). In fact, by using Orthophoto, it is possible to measure 2D elements, obtain 2D vector elements and carry out different analysis (Agosto et al., 2005a); meanwhile it allows an easier communication between the specialized and non technician users, compared to other survey products.

A digital Orthophoto allows to point out and manage information about many elements on the documented object on different layers which is a very important issue in historic conservation and preservation, e.g. architectural elements, shape relationships, construction techniques, material texture, historical phases, color values, decorative elements, decay conditions, etc. (Agosto et al., 2005b; Artesea et al., 2005). Furthermore, the solid image lets the user access and manage 3D data simply by viewing a 2D monoscopic image; it adds correct 3D metric information to simple photos, so that information is much easier to access by users (Bornaz and Dequal, 2004; Agosto et al., 2005b). Actually, digital rectification is the obvious progression from traditional rectified photography and is becoming increasingly accessible, and presents several advantages (Andrews et al., 2005).

Thanks to the rapid development of modern technology of digital rectification software and digital photogrammetry including photomodeler, which has meant that it is now much easier to produce a scaled photographic montage of a historic surface that can be printed out or used in a digital environment. Fig. 1 shows the main process of the digital photogrammetric technique to produce the 3D Model for the left Gate of the stage of Jerash Southern Roman Theatre in Jordan; the camera stations, point determination from several photos and from different angles with known focal length, using control points.

On the other hand, digital photogrammetry methodologies and LIDAR (LIght Detection And Ranging) techniques, in recent years have undergone an important technological progress. Now architectural surveys on historical buildings and archaeological sites using digital photogrammetry and LIDAR methodologies (Bornaz and Dequal, 2004; Artesea et al., 2005) is dependent on:

- the instruments used (degree of reliability and precision),
- representation methods (flexibility degree and amount of information),
- research approaches (degree of exportability, interdisciplinary nature and transformation),
- and means of communication (degree of compatibility with other technologies and ability to diffuse).

One effective solution of terrestrial laser scanning (TLS) is its integration with photogrammetry. Both techniques can be used to complement each other, e.g. when there is a lack of information in occluded areas. Their integrated use, actually, allows complete and accurate survey products to be easily created, while improving the resolution of the 3D model, the accuracy of the objects, the definition of geometries and the colour enhancement. (Rüther et al., 2003; Agosto et al., 2005b, Navarro et al., 2009, Haddad, 2007; Al-kheder et al., 2009).

4. The potential of 3D scanning application in documentation and the non-technical user

New technologies are difficult to be observed by the multidisciplinary community involved in the cultural heritage. Total station applications in heritage documentation needed a good 25 years to become a popular tool. The fast and economic way of creating a Dense Digital Surface Model (DDSM), of the LIDAR technique, is one of the most interesting applications of 3D scanning; if other techniques (e.g. total stations, photogrammetry) where to be used it would be an incredibly time-consuming process. However, the lack of appropriate didactic material, available at academic institutions, and the lack of three-dimensional environment teaching may limit the potential benefits of using full three-dimensional environments. Currently, laser scanning, is only sparsely taught and adequate manuals or guidelines are not available (Santana Quintero and Van Genechten, 2007; Haddad and Ishakat, 2007; Lerma et al., 2008).

Though, the outcome of 3D scanning studies could not be easily understood and obviously appreciated from a majority of the people (archaeologist and architects). Accessing the popularity of this medium needs a strategy to establish guidelines and recommendations for the support of the non technical and untrained users to be familiar with the potential of the technical qualities of this new digital tool according to their actual needs. This will assist to decrease the gap between the specialized technician and non technician users of the 3D laser scanner.

Though, we should start by the modifications required in the nature of the courses in postgraduate study phases; this may be needed, at least, in the Arabic region, where most of the nature of the courses did not consider or understand the value of this most needed and interactive multidisciplinary approach (Haddad, 2007). These guidelines and recommendations should take into consideration the following factors: (1) Acquisition and post processing data, (2) kind, type, scale, material and texture of the cultural heritage object and structure, (3) accuracy and (4) benefit ratio and cost. Following is a general overview of those factors.

4.1. Acquisition and post processing data

The measurement process needs no attendance except for the set-up required when establishing a new viewpoint. Thanks to the digital camera mounted on scanner machines, it is

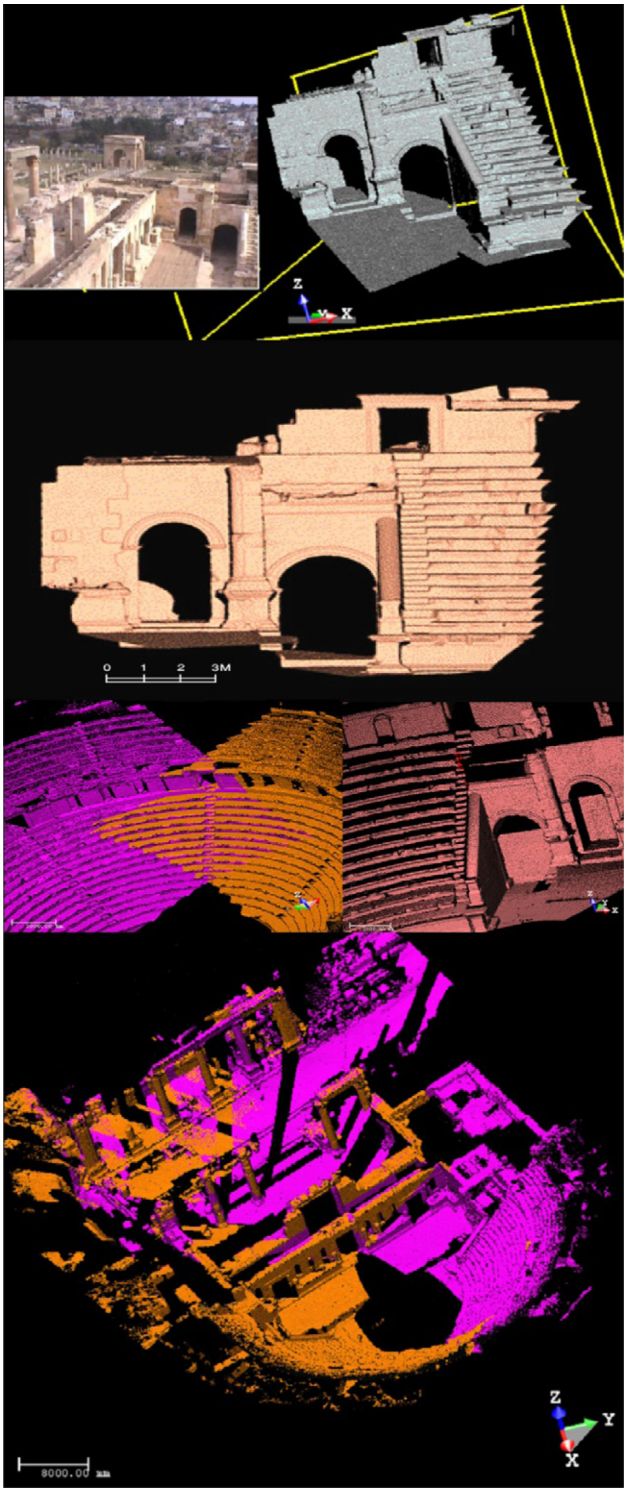

Figure 2 Mesh of 3D cloud points view and overlapping areas and gap registration of two stations of the North Roman theatre at Jerash in Jordan (2006). Additionally, images can be mapped onto the model to get a virtual copy of the real object.

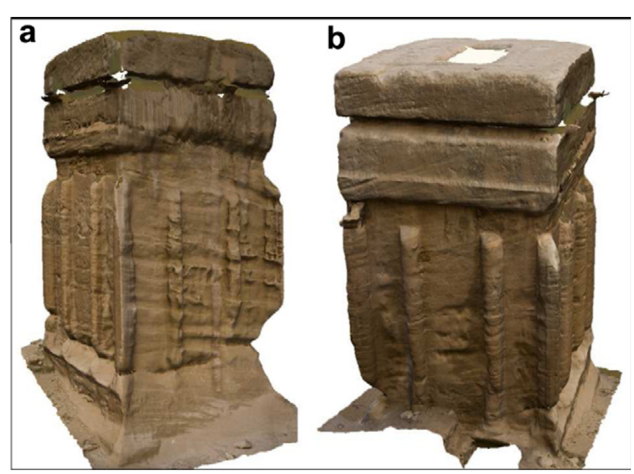

Figure 3 Overall photorealistic model of the Djin Block No. 9 in Petra in Jordan. (a) Western and southern sides and (b) northern and western side (2008).

possible to immediately assign RGB information to each point (Fig. 2). A laser scanning machine can be considered as a high automation reflectorless total station; by means of a laser based measurement of distance and accurate angular movement, a target object is sampled in a regular mesh of 3D points (Figs. 2 and 6). Meanwhile the point clouds produced by 3D scanners are an immediately rich data set, already a starting point for many activities. They are generally not directly usable in most 3D applications, and therefore are usually converted to triangle mesh models (Figs. 2, 3 and 6) or CAD models through a process commonly referred to as reverse engineering so that they can be used for various purposes (Boehler et al., 2005). They can be viewed in 3D (contours and digital elevation model), which permits the viewer see the site in a context that is more closely allied to reality. Additionally, images can be mapped onto the model to get a virtual copy of the real object.

Since obstruction can lead to gaps in survey requiring completion, there are practical limits on the objects size and height in relation to viewpoints (Fig. 5) and may have difficulties on some material surface. It was proved that some parts of the scanned object or site were occluded and thus a larger overlap is required for the complete merging of all scans (Adolfsson, 1997; Kern 2001; Rüther et al., 2003; Artesea et al., 2005; Lerma et al., 2007, 2008) (Fig. 2). As the laser scanning software provides a direct and immediate access to the scanned data, by visually inspecting the point cloud *in situ*, this can assist to identify possible problem areas in the data sets. Table 1 shows different examples of scanned objects like statues, historical buildings and archaeological sites, in relation to number of viewpoints, recording points, scanning time needed in the field and processing time in the lab.

From the examples shown in Table 1, it is clear that, the amount of energy and time to create an accurate and faultless model is many times larger than scanning time (roughly by factor 5 to 10 or even more). However, in the case of the wooden Roman Boat 15 m length 3 m width it was needed eight nights, with 30 view points and 9 million recording points and needed 45 days for post processing. In architecture, as the case of the main support wall of the acropolis in Athens, 20 h were needed for scanning and one day for post processing, which can be considered ideal.

On the other hand, the acquisition time of LIDAR data and processing time is rapidly decreasing and will soon not be a relevant issue. Both, software and hardware have to be improved, to relief the post processing and to make laser scanning an economical option as compared to existing documentation methods. In the meantime, by using an accurate planning and some defined procedures, it is possible to reduce the time necessary for the batch processing (Agosto et al., 2005a; Haddad and Ishakat, 2007; Lerma et al., 2008).

4.2. Kind, type, scale, material and texture of object and structure

Due to the high point density and its availability of a near real time 3D coordinates, 3D scanning will probably yield better results than photogrammetry for objects that are asymmetric, free-forms, irregular surfaces, large and high details building and complex in terms of the number of curves and ridges such as parts of a skeleton and caves. Fig. 4 shows the potential the 3D laser scanner documentation through different mesh view of part of Burgesh cave in Jordan.

In fact, 3D laser scanning technology is particularly well suited for recording landscapes, especially when making detailed inventory records that need to be accomplished rapidly. Such objects are extremely difficult to documented using graphic techniques (Boehler et al., 2005). As compared to tachometric surveying, this equates to a much higher productivity (Haddad, 2007). However, there are some surfaces, which could not scan particularly well (any transparent material such as glass, mirrors, water, and crystal). Transparent objects such as glass will refract the light and give false three-dimensional information.

When the object is rough and dark, much of the laser light is absorbed and missing points can be observed. For example, red bricks were found to respond poorly to some scanners while the mortar provided a good response. However, as reported in literature, marble depart from this hypothesis, and exhibits two important optical properties in this context: translucency, and non homogeneity at the scale of the measurement process. This structure generates two key effects on the geometric measurement: a bias in the distance measurement, as well as an increase of the noise level.

Meanwhile, scanner laser metric data are actually particularly effective in surveying and modelling sculpture and smooth surfaces, they sometimes fail in capturing and detecting sharp edges and lines of intersection, which are essential for a correct representation of architecture (Rüther et al., 2003; Agnello et al., 2005; Lerma et al. 2008). For documentation of object like statues, there is generally a difficulty to place volumetric or reflective targets (Lingua and Rinaudo, 2001). In this case, the use of the ICP (Iterative Closest Point) algorithm can be considered the most effective.

Furthermore, some control points (well visible points) should be used to verify the registration of the 3D images, while external control point scape should be used to obtain the global alignment (Artesea et al., 2005).

Though, the surrounding light intensity, the color and surface of scanned objects are important; it should be emphasized that many limitations in the kind of objects that can be digitized are still present.

Actually, the type of the material hit by the pulse determines the intensity of the returning signal. These sometimes produce a degradation of the quality of the range data and it may even happen that no signal at all will return (Agnello et al., 2005; Andrews et al., 2005). However, in most cases it is possible to modify the surface to make it suitable for scanning; for scanning shiny objects, covering them with a thin layer of white powder will help more light photons to reflect back to the scanner.

By scanning surfaces at an angle of approximately 45°, better-looking results are achieved; the thickness of the cloud of points is smaller because the direction of the main error component is no longer perpendicular to the surface.

However, from the 3D model, it is possible to realize a section with a horizontal and vertical plane in the different zones of interest and immediate measurements which are essential for huge scale and complex structure (Fig. 6).

To do this it is necessary to reduce the amount of processing data between 15–20% before the data post processing (Bornaz and Rinaudo, 2004; Haddad and Ishakat, 2007).

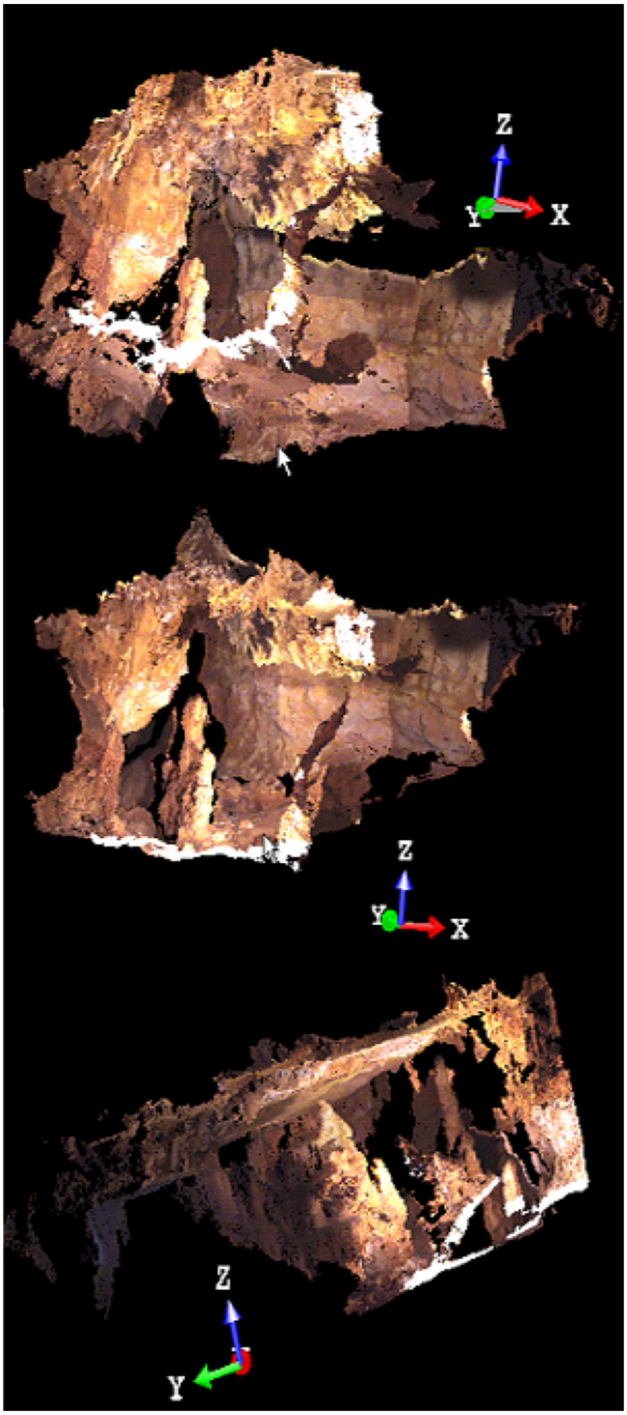

Figure 4 Different mesh view of the 3D laser scanner documentation of part of Burgesh cave in Jordan (2005).

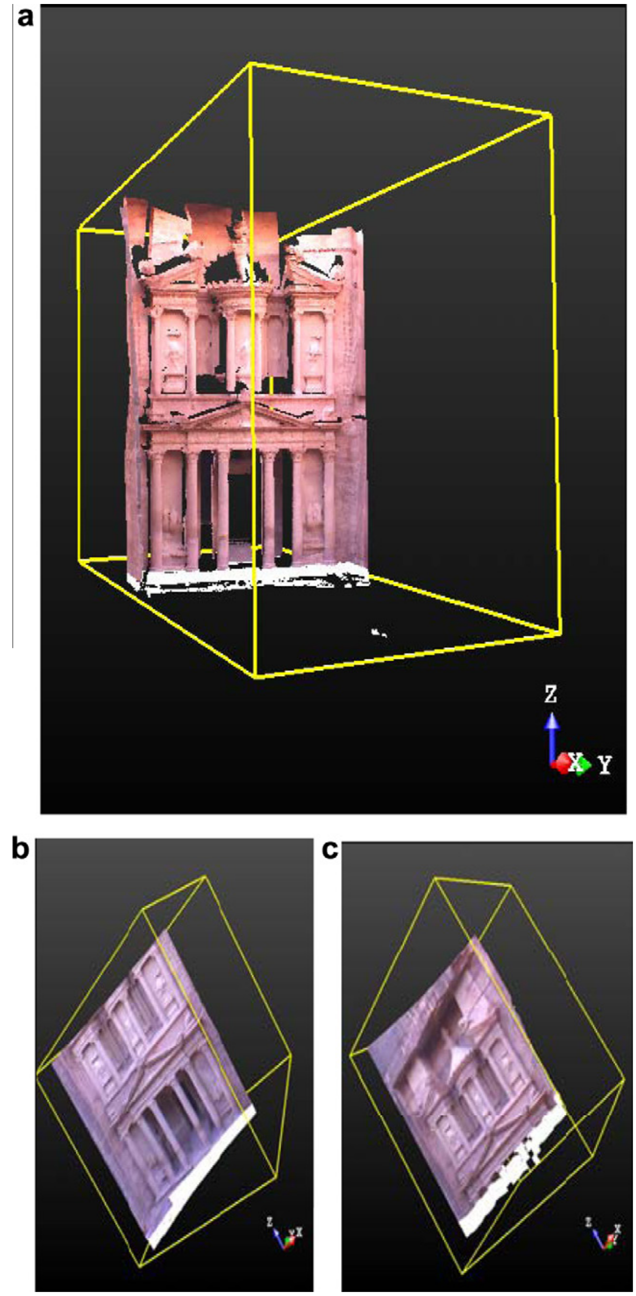

Figure 5 (a) The whole façade of the Khazneh in Jordan was scanned from the front (station 1). (b) The lower part of the Khazneh. (c) The upper part scanned from the right station (2007).

4.3. Accuracy

The accuracy of the laser scanner acquisitions allows detecting some manufacturing characteristics of artistic works, useful for recognizing the paternity of these works (Rüther et al., 2003; Artesea et al., 2005; Haddad, 2007). It is between some millimetres and two or three centimetres, depending to some extent on the available distance between the object and the scanner. From a comparative measurement study using 3D laser scanner and reflectorless total station, it was found that from the 3D mesh model of the 3D scanner we can measure with the same needed accuracy conducted by the reflectorless total station. The accuracy average is between 0, 5 and 2 cm (Haddad and Ishakat, 2007).

Although surveyors tend to see accuracy as a predominant consideration when comparing measuring equipment, for the practical use there are numerous other characteristics which may be decisive under certain project pre-conditions. This also applies to the suitability of 3D scanning equipment. The accuracy depends on both the length of the scanner base and the object distance. With a fixed base length, the standard deviation of the distance measurement will increase in proportion to the square of the distance. It can be predicted that point

Table 1 Examples of different scanned objects in relationship to different variables.

Object scanned	View points	Recording points/million	Scanning time (field)	Processing time (lab)
Bronze statue, 80 cm height	11	0.780	1 day	10 days
Wooden Roman Boat, 15 by 3 m	30	9	8 nights	45 days
El-Khazneh at Petra, Jordan, 40 m height	3	4.7	1.5 h	Approx. 1 week
Tobacco Warehouse Xanthi, Greece	6	6.59835	5 man hours	2 man hours
Grave Mound at Kirchheim Osterholz, Baden-Wuerttemberg, 10 ha	–	20	5 h	5 days
Fort at Saalburg Hessen, 30 ha	–	125	7 days	25 days
Koerich Castle, Luxembourg, 0.3 ha	–	35	1 day	15 days
Theatre "Linz", Austria	26	–	20 h	2 days
Inner city excavation, Ulm 7 by 8 m	–	–	6 h	7 days
Acropolis wall, Athens	–	–	20 h	1 day
Stone statue (Marc Anton) high 3 m	10	7.4 reduced to 4.0	2.5 h	–
Sandstone sculptures, 4 by 10 m	3	3	2 h	–
Room Camin Nero in Buonconsiglio Castle	4	–	30 min	–
Augustus Triumphal arch Aosta, 17.5 m height	19	30	2 days	–
Room Torrione da Basso in Buonconsiglio Castle	3	–	30 min	–
Celtic Oppidum at Titelberg, Luxembourg, 50 ha	–	120	1 week	–

accuracy is constituted only by the accuracy of the distance from the laser mirror and that this accuracy decreases with the square of this distance (Boehler et al., 2005).

However, with triangulation scanners 3D point standard deviations is less than one millimetre at very close range (less than 2 m). Good surface-determination obtained even with low single-point accuracy because a large number of points exist. Actually, laser scanning accuracy cannot reach the accuracy of geodetic instruments and does not provide the possibility to increase accuracy through larger image scales as can be done in photogrammetry.

While there is no improvement in the accuracy using laser scanned data, mainly because of the large number of overlapping photos which should be taken, there is a significant gain in labour associated tasks. The comparison between Orthophoto derived from: (a) typical photogrammetric process, (b) use of DEM derived from laser scanning and implemented in the Orthophoto, and (c) use of DEM derived from laser scanning and photogrammetrically derived breaklines, revealed that very small systematic deviations existed and the achieved accuracy satisfies the specifications at scale of 1:50 (Costantino,2001). However, specifications stated by the producers are not comparable.

4.4. *Benefit ratio and cost*

Actually, it covers most of the needs for users involved in historic sites conservation and preservation as it can be directly used for 3D visualization, point to point measurements just like if the user were physically present on the site and stored for subsequent use. Still it is very expensive, need high skilled operations and post processing can be time consuming, while editing the data to produce meaningful results may be difficult. However, the increasing of computers performances allows management of very large point clouds, and helps discover interesting perspectives for the utilization of 3D models.

3D Laser scanner should be considered as one of the most effective instrument for monitoring (3D monitoring). On the other hand, the scanned data are tied to real world coordinates which makes it possible to be used for GIS or spatial statistical analysis. We can also present the scanned object and propose an interpretation established in advance or try to offer to visitors all the necessary elements in order to understand and evaluate autonomously, especially the navigable 3D model which can be easily generated.

This kind of model is an extremely useful tool to make a representation of a complex object and has a remarkable impact on the public seeing 3D products in a show room. Such a tool would be placed internally at an archaeological site allowing the exploration of the surrounding space enriched with graphic and precise information. However, an untrained user could find this representation not so easy to deal with (Agosto et al., 2005a, b; Lerma et al., 2008).

5. Summary and concluding remarks

In comparison with other issues of the cultural heritage (conservation, preservation, restoration, and protection), the impact of modern technology the last 20 years is obvious and clear in the rapid evolution of the documentation techniques and tools. To achieve a real comparison between these methods the cost and time play a major factor, while size, complexity, level of accuracy required, monitoring issue are also leading parameters.

Consequently, in order to obtain a correct representation of large complex historical structures, it is necessary to plan specific survey and representation techniques. In fact, when dealing with documentation, the correct procedure is to plan and manage different survey techniques, considering the user needs. We can conclude that, a combination and integration of different methods often leads to the best results and less time, while the integrated use of LIDAR and digital photogrammetry allows 3D accurate metrical models for the presentation and interpretation. However, among the several techniques used for the documentation of solid objects, 3D laser scanning has shown that it has the potential to be of major value to recording professionals.

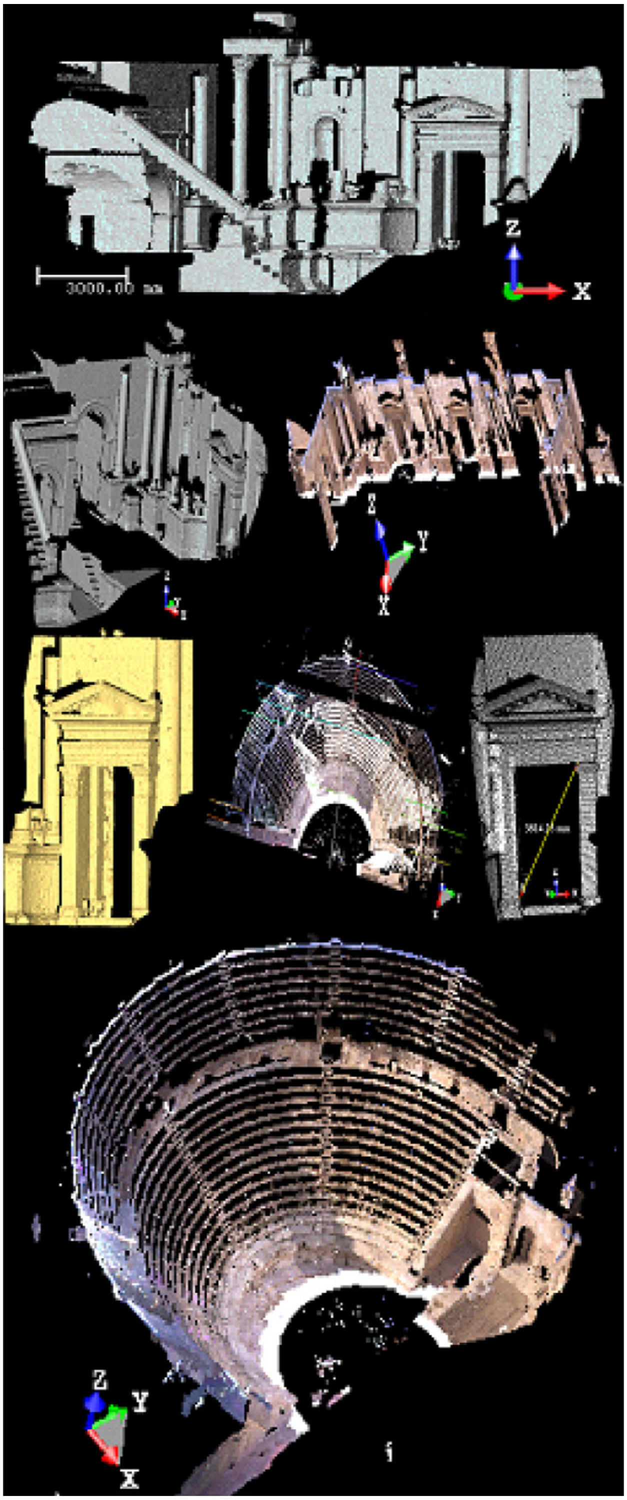

Figure 6 Mesh part of the scene, the northern gate and cloud points the caves of the Southern Theatre in Jordan (2005). Three stations were set up to capture points from different angles. The resulting point cloud can be used to extract CAD elements or – by using point triangulation – to create a 3D surface model.

Laser scanning has the main advantage of allowing the acquisition of dense data sampling with high accuracy, high speed and flexibility in 3D digital data format. We can assume that, laser scanning in certain applications will replace some of the existing methods and can play a significant role in monitoring. Monitoring now should be the new target for the technical and geodetic people involved in the digital technology of documentation. Indeed, 3D Laser scanner should be oriented and considered as one of the most effective instrument in monitoring of the remains of past human activities.

However, documentation is not only needed for proper conservation and preservation, but foremost to raise public awareness. 3D digital models can facilitate generation of historical and archaeological experiences using the techniques of computer animation, while reducing the need to reconstruct the historic sites. Such investments are effectively useful and really increase and diffuse knowledge in cultural heritage and satisfy users' requirements.

Therefore, the users that belong to the strict portrayal-school should now accept that they have to deal in the field, with other new documentation and interpretation methods, instead of hand measuring and tachometry. A dialogue must now be created between the specialized technician and non technician users, involved in the process of documentation; they must now not aim for the precision and accuracy required, but for 3D standards, interactivity multi-media visualization production system, which will play a major role in interpretation and preservation of historic sites. This can now actually be achieved by the digital technology.

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