# Using Close Range Photogrammetric Techniques as a 3D Source for Egyptian Monument Information System

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**Abstract**
*In Egypt, sites, monuments, and archaeological traces bear witness to a long history that goes back to the far recesses of prehistory and the dawn of civilization. Egypt is rich of monuments which make it one of the most famous countries all over the world. As everybody knows that one fifth of the world's monument located in Egypt. These monuments need to be documented in a way that makes it available for everybody all over the world to visualize them in real 3D and have all the information about them. This will be possible if we could put them in a system able to give the users all the possible information in text, 2D and 3D forms. Digital close range photogrammetry is the best tool to provide 3D models of the monuments in a real shape for an information system as it has a wide use in the archaeological field. Digital Projector technique is presented as a proposed technique to be used for documenting the Egyptian monuments in 3D computer model form with their real shape. This paper will illustrate the ideal digital close range photogrammetric method to be used as 3D source for an Egyptian monument information system.*

## 1. Introduction

It is well known that the photogrammetric science is widely used in the applications of the archaeology. As it is a remote method of measuring from photos and collecting information about the targets, it is considered as the best way to be used to carry out different jobs in the archaeology field. Archaeology is defined as the branch of anthropology that studies prehistoric people and their cultures (Site 1). There have been also multiple definitions of what archaeology is through the history of the discipline. Several of these definitions define archaeology as a discipline largely concerned with artifacts, in particular pottery, potshards, and arrow points, or with the excavation of large scale sites such as palaces and ancient pyramids. By focusing upon less obvious remains, the science itself has shifted from a study dominated by treasure hunting and half composed (if not totally incorrect) theories of culture, to a science which attempts to understand holistically the context and culture of a given site and the gross overall completeness of a culture (Site 2). A lot of precious old cultural heritages remain all over the world. These heritages are of great value for human beings in both history and art. Some of these old cultural heritages face a crisis in that these are going to fall to ruin naturally and/or artificially. These sites become gradually worse by weathering, plants, animals and human activities. Appropriate treatments for these are urgently requested at present. Although various technologies have been attempted to preserve or restore old cultural heritages, it is very important to record the current status of the object precisely and preservation or restoration histories of them accurately. These records are necessary to monitor status of both damaged parts and restored parts of the target. A restoration researcher can make an appropriate preservation or restoration plan based on these records. However, precise and accurate records of an old cultural heritage are not necessarily available. Precise records of the current status of the object have been available by photogrammetric technique (Hongo et al., 2000). The graphic representation of historical monuments is traditionally performed with the assistance of tape measure. With this purpose, all the necessary elements for its representation are based on direct measurements on the monument. These measurements are time consuming dependent on the conservation state of the monument. They can even damage the monument. After the Second World War, the conservation of monuments was motivated, leading, in 1964, to elaboration of the International Charter about conservation and restoration of monuments, known as Charter of Venice. Since then, several countries began to establish programs for maintenance of their historical monuments. The International Council of Monuments and Sites (ICOMOS) recommended that each country should constitute a photogrammetric record of its monuments and sites, since photogrammetry is considered the main and more advanced method for surveying (Silva and Dalmolin, 2000). There is no doubt that there is a great need to find out a way to document our heritage in a reasonable way which keeps it safe along with all its fine details. Much research has been done to preserve the world heritage for future use incase of accidental damage or willful destruction. Also, with the great developments in computing, the use of graphics and 3D modeling, different visualization methods have been developed to show our heritage to the people all over the world. Documentation and conservation of cultural heritage are being increasingly seen as tasks of national, ultimately international priority. Due to the digital techniques, photogrammetry now appears as more efficient and inexpensive; today's user-oriented software is easier to handle by non-experts, thus widening the potential spectrum of application in architectural and archaeological recording (Patias et al., 2000). In the past, the only way to document world heritage was to write the target's description in files and then keeping them in a safe place. This method was not very effective since it was prone to accidental loss or damage (through fire or poor archiving practices). Since photogrammetric science has existed, the archaeological photogrammetry has been used in the field of archaeology for several reasons and applied in several projects. The term "Archaeological Photogrammetry" is defined as the use of the photogrammetric types and techniques in the field of archaeology. It is considered as one of the most important applications of Photogrammetry (Slama, 1980). Archaeological photogrammetry can be applied for Prospection and Landscape Archaeology, Excavation, Recording of Caves, Mining and Cave Paintings, Recording of Finds, and documenting the world heritage (along with their finer and more subtle details). All the photogrammetric types (aerial, terrestrial, close-range) and techniques (analog, semi-analytical, analytical, digital) are used in the Archaeological field with using metric or non-metric cameras, soft print or digital. Nowadays, with the development of the computer science and its uses, the documentation of world heritage has become easier and more accurate because of the use of something called "Digital Photogrammetry". This allows the tasks to be performed easily and mainly depends on imagery and computer models and many methods, techniques, and software are used to document the world heritage. Some of these methods require a special technique and custom software, but some others use existing commercial software. The photogrammetric science has a wide range of use in the field of archaeology as it can be used by measuring from photographs without physically touching the target. It is therefore considered as the best way to take measurements of archaeological sites and monuments. The ICOMOS has recommended that photogrammetry be used as the best way to take measurements from the archaeological sites and to acquire information about the monuments, as it is the more accurate and safe way. Different types and techniques of photogrammetry are used in the field of archaeology for excavation, prospecting the archaeological landscape, recording of caves mining and cave paintings, recording of finds and documentation the world heritage including the historical building. The Supreme Council of Antiquities (SCA) is the organization responsible for the registration of the Egyptian cultural heritage (Site 3). The Documentation department (Center for recording) determines what data is to be registered. It was first established in 1956 as a convention between UNESCO and The Egyptian Government, at that time, for documenting the buildings that were to disappeared because of the High Dam construction, Nubian monuments from Abu Simbel to Philae - Aswan governorate, upper Egypt. This center is nowadays officially responsible for the recording of all Egypt's cultural properties, by all necessary grayscale photos/slides, written descriptions, sketches, etc. These documents and related articles, drawings and photos are to be kept at the microfilm archives that can be accessed only by officials or for a fee, by persons with official credentials to study these archives. Until 2001 the only recommended method of photo recording was black and white. These archives and computer digital archives were established in 1985 for documenting the paperwork. Currently no public access is allowed for these microfilm archives. The Center has recently trained the new staff at the SCA on appropriate recording methods. There are several project and programs nowadays are running in Egypt to document its heritage in a reasonable way. Some of them are using GIS as a database for documenting, analyzing, and visualizing the monuments. For example, the Archeological Map of Egypt program is a multidimensional program aiming to employing the latest information technology to produce a powerful documentation and management tool for the Egyptian archaeological sites that are spread all over the country. It involves dividing the information of the archaeological sites into three levels (National, Sites, and the Monuments level) and using the multimedia technologies in conjunction with the GIS to document the archeological and geographical details of each monument (Site 4). Figure 1 shows the Archeological Map of Egypt.

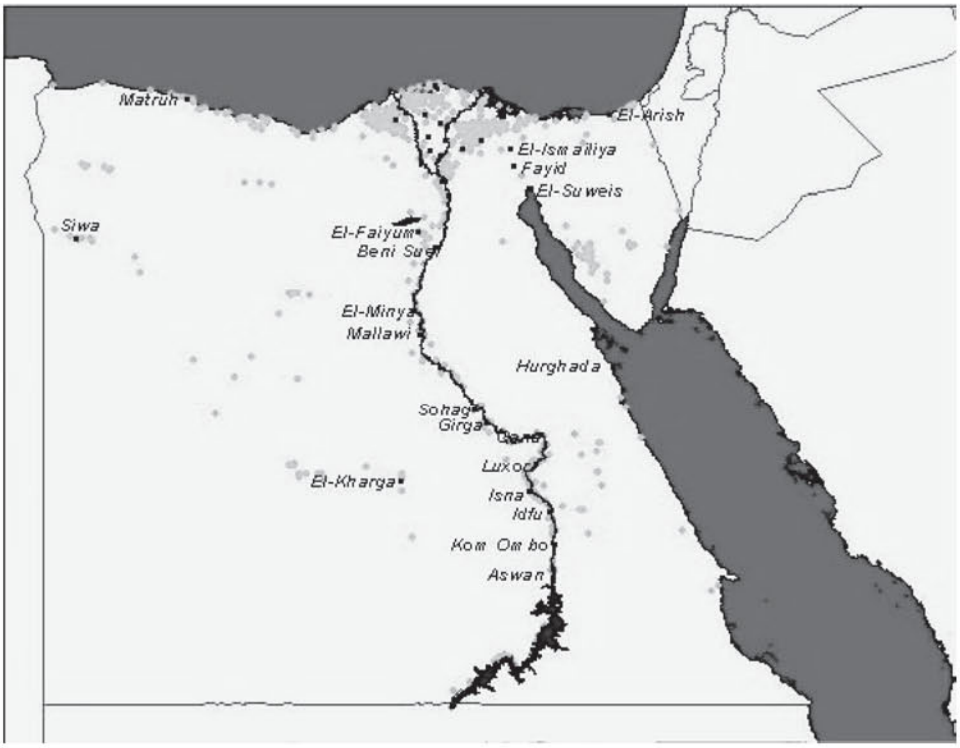



Figure 1: Archaeological map of Egypt (Site 5)

3D recordation and visualization is an emerging field, developed out of the GIS mapping, high tech, and computer modeling industries. Where most GIS and other spatial modeling relies on two-dimensional data input and output, 3D recordation and visualization incorporates height and elevation to enhance accuracy and realism. Some GIS applications, such as ERDAS' Virtual GIS and ESRI's 3D Analyst/ArcScene, are already taking GIS data into 3D space. However, even this modeling often is not truly 3D. The term "2 1/2-dimensional" was coined to describe the "3D" GIS environment in which there is elevation and contour, but no "underneath" detail. (Site 6). 3D recordation and visualization approaches can be applied to archaeological material, and therefore to fairly small features and objects, ranging from about 100 feet to a few inches in size. Another example, in the year 2000, the Government of Egypt and the Government of Finland financed a new project for Egyptian Information Antiquities System (EAIS) to establish a Geographic Information System (GIS) for the management of historical sites in Egypt. This project is to have complete metadata and exact site location over Egyptian Traverse Mercator (ETM) coordinate system. This project is responsible for holding the GIS of all the Cultural immovable heritage of Egypt.

In November 2004, approximately 20% off all the data and sites of Egypt, and 5-6 Governorates was completed. The maps are now available to scale 1/2500 for all the Pharonic sites all over Egypt (Shenouda, 2005).

## 2. Objectives

From the previous review, we can conclude that the digital close range photogrammetry has a wide use in the world heritage documentation including of course the Egyptian's. There are several tries to document the monuments in a 3D shape, but none of them tries to document them in a real shape. The objective of this paper is to present the digital close rage photogrammetry as the ideal technique for documenting the world heritage in a real 3D shape with the ability to visualizing them in different ways through an information system. A new technique which called "Digital Projector" (Ebrahim, M., 1998) is applied to document the objects in their real shape to be presented as a 3D source for an Egyptian monument information system. GIS is the best environment to deal with such documental as it will document our heritage in different shapes as text, images, animation, VRML, and movies. This could be the start of establishing an information system for the Egyptian's monuments with their 3D real shape that called "Egyptian 3D monument information system".

**3. Methodlogy**

Several photogrammetric methods are used for world heritage documentations. All of them are different in techniques or in visualization. At past, the world heritage documentation was done by writing the target description in softcopy files. Sometimes photos were taken additional to the description of the target. Nowadays, the digital methods have taken the first place in documenting the world heritage. In the next sections, a full description of the used digital photogrammetric methods in the field of the world heritage documentation (rectification, draping, digital projector) will be presented proposing the digital projector method as a better method for documenting the Egyptian monument in it real 3D shape.

*3.1 Rectification*

The rectification techniques normally deform the original image so to eliminate non-parallelism effects of focal plane of the camera and of the object to survey. Having an image, in a raster form, there are some simple algorithms that permit rectifying operation in an effective way and without particular limits. Among the points which build up an object plane and the points which build up an image of the same object obtained with a camera, there is a relationship that hang together every point of the object to a point of the image and vice versa (Fondelli, 1991). The rectified photography method has continued to provide a valued product and is still produced through photogrammetric resources. However, some groups such as archaeologists have taken to this method quite extensively. The technique continues to be carried out in a very straightforward way. Equipment need not be metric, professional cameras and conventional enlargers being quite adequate. The camera (or more strictly the negative or focal plane) is aligned parallel to an area of facade. Scale is introduced in some way, and the resulting photographic point is produced exactly to this defined scale. Today, with a powerful PC on almost every desk and with numerous software packages around, digital methods for rectifying images are becoming extremely lucrative. Several commercial companies and research institutes have produced and currently marking relevant software, which takes care of camera tilts. A couple of available packages have been described in Geogopoulos and Tournas, 1994. An interesting research towards a low coast digital rectification system is reported by Patias, 1991. Atkinson, 1996 has mentioned some of the used software in rectification such as Fotomass and Galileo Siscam (now Selesmar Siscam). Essentially, these programs either take in a scanned image of a photograph, or work from the digitizing of points on the photographic image on a digitizing tablet.

*3.2 Draping*

Draping is a type of covering the 3D model by the rectified image. It called sometimes “bitmap” or “texture map”. There is a lot of trying to obtain the architectural object with its real shape as a 3D model. The main idea of draping is to make a rectification for the images, which will be used first, then assign them to the correspondence part in the 3D model to be rendered through a rendering software. Pomaska G., 1996 has stated that photorealistic rendering is based upon assigning materials to the entities of a CAD-model. In addition to the material model, a light model has to be designed. Materials are bitmap patterns, which are repeated like tiles in columns and rows until the entity boundary is completely covered. So called bitmap decals are not tiled. They consist of a single instance of the image. A bitmap decal has to be scaled correctly to fit the planar mapping projection. If the source of the bitmap does not deliver the appropriate scale, a scale factor in x- and y-direction can be defined. Calculation can be performed from pixel information delivered by the digital imaging software compared with the dimensions from the drawing editor. Orientation of the bitmaps has to be defined through an origin point in the x-y-plane. Excluded color options allow masking from the bitmaps. The effect is that the background is visible through those masking areas. Streilein, 1996 has draped a texture map with original image data on a CAD model of Otto-Wagner-Pavillon by using a JVC GR-S77E camcorder video camera. Wiedemann, 1996, has presented a new approach for the generation of architectural orthoimages using surface models, based on a CAD model of the object.

*3.3 Digital Projector: (Proposed Technique)*

The concept of the "digital projector" is on the one hand a new rigorous digital photogrammetric tool and on the other hand takes into account the demand for an object oriented, three-dimensional reconstruction of monuments (Ebrahim, 1998). Considering an architectural restitution first a complete reconstruction of the building’s shape has to be done using e.g. any digital matching methods (e.g. Streilein, 1995) or a bundle adjustment program (Kager, 1980) followed by a definition of lines and surfaces in a CAD environment. A few of the already used images are then chosen to do a “digital slide projection” onto the surface to achieve a restitution of the object details.

The surfaces of the different objects are not restricted to planes but were also of regular curved shape (e.g. cylinder etc.) and even irregular or free formed shape. On the contrary to the conventional "rectification" of metric photographs the "Digital Projector's" concept is a strict object oriented three-dimensional restitution of the whole object without almost any conditions and limitations. The approach is based on a reversion of the situation during exposure. The process of reconstruction of a monument to get a virtual computer model happens in 3 steps. In the first step the cameras inner geometry and its position and orientation during exposure as well as the building's characteristic framework of outlines and faces is to be reconstructed mathematically using PhotoModeler software. To get a homogenous solution of the total object these elements are computed in a so-called "bundle adjustment" where a probable result of the whole measurement system will be created. Beside of this way the restitution of the outlines may also come from an analytical plotters result. In the next step within a CAD environment this framework will be reviewed and if necessary completed where also additional measurements (photos, tape, theodolit, etc.) can be added using AutoCad software. After that the 3D model will be closed defining faces between the structure lines and will be investigated for leakage performing a rendering process. The face model that arises from that step will be used as a kind of "projection screen" and can be of very different degree of details using 3D studio Max software. In the third step happens the actual re-projection of the photos (Hanke and Ebrahim, 1996). Similar to a slide projector some selected photos are projected to the surface model of the monument. The selection is done regarding the visibility and its direction of projection. The "Digital Projectors" own the same inner geometry and relative position as the related cameras. These values come out of the bundle adjustment can be different for all cameras. As the restitution is strict object oriented there is no problem combining very different photos of the same object. The use of close shots for interesting details and overview shots to include neighboring objects with less resolution of projection is also possible without problems and shows the flexibility of the approach. It is also possible to combine the inner and outer parts of a building. Some of the projectors just have to be situated in the inner space and do the virtual projection onto the inner walls. Using this method, any measurements of any details on the object can be done easily. No detail of the object can be neglected, none can be forgotten, and no prior filtering of details has preceded this using.

The full information of the original photos is available in the results. The accuracy that can be achieved is mainly correlated to the particular of details on the geometric reconstruction of the object. This method leads to an accurate 3D virtual model of an object in its real shape and with all of its details as long as photos are available. The method aims mainly to close range applications in architecture and archaeology but can also be useful to any other kind of realistic photogrammetric 3D restitution even aerial applications will mean no problem.

## 4. Practical Case

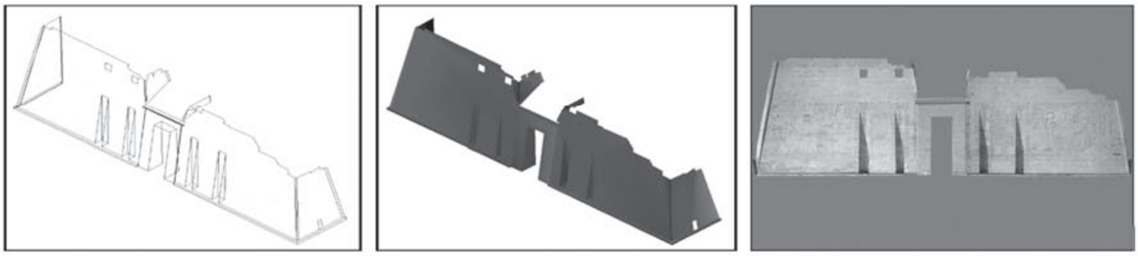
Three practical applications were done through this research using the digital projector method to produce 3D model for some Egyptian monuments with their real shape. Such 3D models are the best source for a system like GIS to be used as documentation database with all graphical details and information. VRML, animation, still images from any point of view, and movies can be a result of such 3D models. In next sections, the two applications will be presented.

### *4.1 Ramesses Iii Temple (Luxor, Egypt)*

It is one of the old Egyptian temples which have been built in the west bank of Luxor city for Ramesses III (ca. 1182 - 1151 B.C.) as a Mortuary temple. It is very big temples which have a lot of rooms and a big hall with columns in each side. The temple's walls have a lot of details which shows to be very good for mapping. Thirteen photos have been photographed for the main front entrance of the temple by using a non-metric camera Yashika 35mm from different positions. The photographs have been converted to Kodak Photo CD. Seven original images have been chosen to do the digital mapping to map the details of the temple's main entrance. Figure (2) shows some results of the 3d model of Ramesses III temple.

### *4.2 Obelisk Project (Paris, France)*

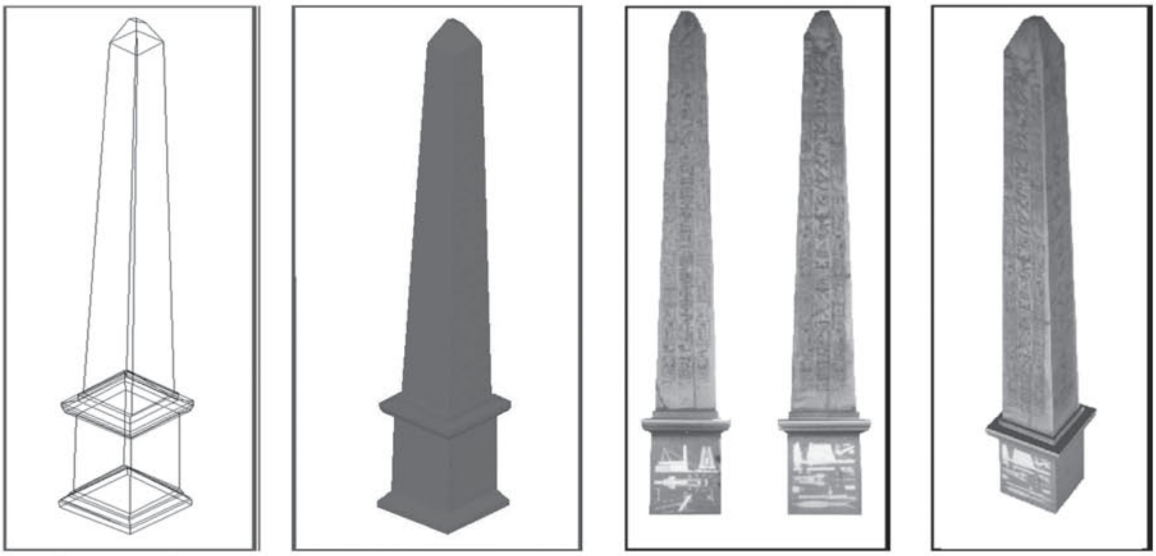
It is one of the old Egyptian obelisks, which was a gift of the viceroy Mohammed Ali of Egypt and was brought to France in 1833. It stands on the Place de la Concorde in Paris, France. The natural of the object is very easy because it consists of a plan faces and has no curves and no complex surface. Four images have been taken by the author using a normal camera (non-metric) Yashika 35mm from each corner of the obelisk. The photographs have been scanned with desktop scanner (Agfa ARCUS II). Three images from the original images have been chosen to do the digital mapping. Figure (3) shows some results of the 3D model of the Oblisk.



**The object wireframe** **The rendered model** **An orthoimage**

**Perspective view** **Left part zoomed view** **Right part zoomed view**

**Figure 2: Some results of the 3D model of Ramesses III temple**

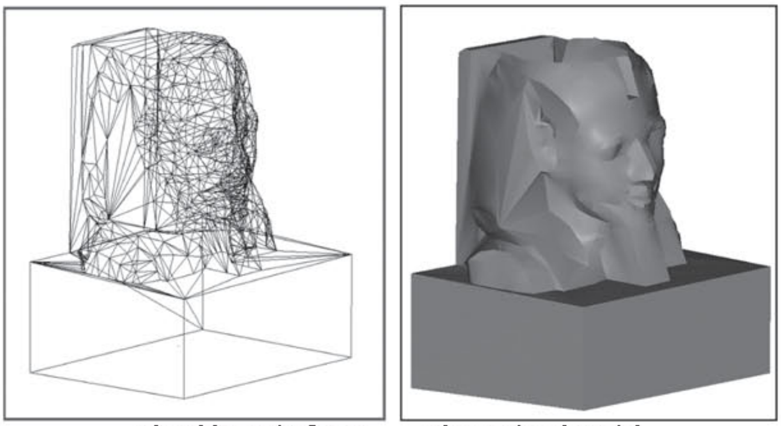


**Object Wireframe** **Rendered Oject** **Object Orthoimages** **Perspective view**

**Figure 3: Some results of the 3D model of the Oblisk**

***4.3 Statue Head (Luxor, Egypt)***

**It is one of the old Egyptian statues' head for one of the old Egyptian Kings which laid in front of the main entrance of the Luxor temple in Luxor city. It has been made from marble. It is one of the most difficult projects because of the natural of the object. It has irregular surface which need a lot of points to be marked to define the face of the statue's head. This project has proofed that the Digital Projector method works very well with all kinds of surface and for any 3D-model. Nine images have been photographed around the statue's head to photograph all the details of the head by using a non-metric camera Yashika 35mm. The images have been transferred to Kodak Photo CD. Four original images have been chosen to do the digital mapping. Figure (4) shows some results of the 3D model of the statue's head.**



The object wireframe          The rendered model

An orthoimage          A perspective view

Figure 4: Some results of the 3D model of the statue's head

**5. Conclusion**

Our heritage is our past reality, which gives us an insight into what has happened and how life actually was. Some of the heritage has been excavated whilst much more has not. Our cultural heritage is not confined to the visible architectural remains. Most of the archaeological sites are still hidden in subsoil. Many of them are increasingly threatened with destruction. The main threat is erosion due to intensive agriculture, which is accelerated by large-scale consolidation of farmland. Furthermore the construction work that is carried out, as for rail- and roadways and the exploitation of our mineral resource are constantly destroying archaeological sites. In this way, large amounts of our cultural heritage, which had survived thousands of years protected by soil, have been irretrievably destroyed within a few decades. For many years now photogrammetry has played a significant role in documenting the cultural heritage of various nations and peoples, and many recent advances in this invaluable technique have enhanced the use of photogrammetry as a recording technique. By using the different photogrammetric techniques in the archaeological field, we could do a lot of work to preserve, conserve, and document our world heritages. Digital close-range photogrammetry takes the part of documenting the monuments and the sites in details. Different techniques are used for documenting the world heritage. Some techniques do the job completely and some techniques have obvious limitations. Digital Projector technique is an ideal method to produce 3D computer objects which can be used to document the world heritage especially the Egyptian monuments for a new Egyptian monument information system.

Much research has been carried out to demonstrate that photogrammetry is the best way to keep a more accurate record of our cultural heritage. It is the best technique that can produce 3D models with their real shape that can be considered as the best GIS 3D data source. It can provide GIS with 3D model in different shapes along with different visualizing formats. We can conclude that without photogrammetry, the archaeologists would require thousands of years of effort to do the job that photogrammetry is currently achieving.

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