THE OSIRIS PROJECT
(OPTICAL SYSTEMS FOR INTERFEROMETRIC-PHOTOMETRIC RELIEF INVESTIGATION AND SCANNING),
DEVELOPMENT OF A DEVICE FOR 3D NUMERICAL RECORDING OF ARCHAEOLOGICAL AND EPIGRAPHIC DOCUMENTS
BY OPTOELECTRONIC PROCESSES

D. Laboury*, Y. Renotte†, B. Tilken‡, M. Dominique§, R. Billen*, Y. Cornet*

* Egyptological Dept. and Interdisciplinary Center for Archaeometry of the University of Liège (ICAUL), University of Liège, 13, route de Marche, B – 4019 Xhoris, D.Laboury@ulg.ac.be
† HoLab, Dept. of Physics, and ICAUL, University of Liège, allée du 6 Août, 17, B-4000 Liège, (y.renotte, B.Tilken, M.Dominique)@ulg.ac.be
‡ Dept. of Geomatics and ICAUL, University of Liège, allée du 6 Août, 17, B-4000 Liège, (Roland.Billen, ycornet)@ulg.ac.be

KEYWORDS: Archaeology, Optical Engineering, Metrology, Moiré, Photogrammetry

ABSTRACT:
Archaeology is permanently confronted with the problem of recording the objects of its study, since excavated relics of the Past are always exposed to a progressive and often irremediable process of defacement, and, finally, of annihilation. In order to find a solution to this very important and still unresolved problem, the OSIRIS project aims to develop one or several devices that allow by optoelectronic processes an accurate, quick and easy to use recording, dedicated to the specific and very demanding needs of Archaeology.

RÉSUMÉ:
L’Archéologie est continuellement confrontée au problème du relevé des objets de son étude, de par les altérations qu’implique nécessairement, et souvent irrémédiablement, la mise au jour des vestiges enfouis du passé. Afin d’apporter une réponse à ce problème crucial, qui n’a pas encore trouvé de solution idéale à ce jour, le présent projet se propose de développer une ou plusieurs techniques de relevé opto-électronique qui permettent un enregistrement précis, rapide et souple d’emploi, appliqué aux besoins spécifiques et particulièrement exigeants de l’étude archéologique.

1. INTRODUCTION
Archaeology, as the Science which studies the material remains of human behaviour, naturally stands at one of the crossroads between the human Sciences and Science (physics, chemistry, biology, geology, geography, …). This connection is precisely a way to define what we are nowadays used to name Archaeometry, that is the combination of laboratory techniques with the traditional methodology of the historical and archaeological investigation to deepen the analysis, the knowledge and the interpretation of ancient works of art, monuments and archaeological objects. Archaeology is also permanently confronted with the problem of reading, recording and conserving these material traces of human behaviour which constitute its investigation field. The basic principles of the OSIRIS Project are these very two essential dimensions of archaeological research: on one hand, Archaeometry, the synergy between historical Sciences and the laboratory techniques of Science; and on the other hand, the study and conservation of material remains or traces of the Past.

2. THE TRADITIONAL RECORDING TECHNIQUES IN ARCHAEOLOGY AND ART HISTORY
The recordings needed by the different aspects of the Archaeological research have a double aim: the creation of a medium allowing to publish in the more accurate way the studied object; and, even more importantly, the virtual conservation of this object, or, at least, the conservation of the historical information (in the broadest sense of the expression) it reveals and preserves.

The conservation of archaeological objects is far from being a simply theoretical problem. Indeed, in its very process of revealing the relics of the Past, Archaeology is by definition destructive: it always destroys the containing of the object it aims to reveal, and the thus revealed content is then exposed to new aggressions of its surrounding world, which in many cases will damage it irreparably on a relatively short period of time, in comparison to its age. No monument can avoid this phenomenon of deterioration and, finally, of destruction. The case of Ancient Egyptian architectural heritage, whose study is at the root of the OSIRIS project, clearly exemplifies this; the especially dry, chemically and hygrometrically stable desert ground of Egypt naturally allows the long-lasting preservation of archaeological objects, even the more fragile ones, like millenary papyrus, wooden artefacts or textiles. But, once exposed to the open air, to its climatic variations, to nowadays pollution and to human aggressions of all kind, these relics of the Past decay at a very impressive speed, even those made in the very hard stones (Figure 1, Bell, 1987, pl. 1).
Nowadays, numeric image technology offers an almost infinite flexibility of use, with which traditional drawing techniques cannot compete. And, unlike photographic images, digital pictures do not suffer any natural damage that compromise their ‘life time’. Moreover, recent developments in Optics and Optoelectronics allow now a real global 3D recording, in the same time faster and more reliable. Coupling these new technologies gives enormous advantages regarding the flexibility and the easiness of recording, processing, reading and storing; it also offers the possibility to imagine new ways of publishing ancient monuments, in an electronic form, more realistic, more accurate and more interactive, as a real 3D structure and not anymore by means of fixed and inaccurate 2D images.

4. THE AVAILABLE TECHNIQUES

There exist a few projects of global scanning of ancient artefacts (Clarke, 1998; Taubes, 1999). They reveal the existence of technological solutions to the fundamental problems raised by the recording of archaeological and monumental heritage. But, until now, none of the already available scanning devices is able to work in real in situ conditions (for example under the sunshine of Egypt), on large scale, and with the precision needed for archaeological and art historical research. So above all, they are some kind of laboratory apparatus, very difficult and often impossible to use in normal archaeological context, that is on site and on large scale. Thus the problem is still unresolved.

Optical recording of the relief or the 3D shape of an object can be achieved by using two principles: the stereoscopy and the triangulation.

The first one, stereoscopy, requires, as its name tells, two views of the same object but taken from different points of view (stations). Using the parallax deformations, it is possible to reconstruct the examined object in 3D. This very well-known principle is amply used by human vision and is the basis of photogrammetry. Some preliminary researches made by the Department of Geometry of the University of Liége (notably in the SURFACES Laboratory [Service Universitaire de Recherches Fondamentales et Appliquées et Cartographie et Étude Spatiales; dir. Pr J.-P. Donnay], in close cooperation with the ICAUL [Interdisciplinary Center for Archaeometry of the University of Liége; dir. Pr D. Allart; project dir. Dr D. Laboury]) have shown that it is possible to find a solution to the recording problem of Archaeology and Art History with digital photogrammetry. The project aims to develop a photographic set-up conceived in order to present a certain flexibility and an easy handling which will enable the 3D numerical recording of archaeological objects through a terrestrial photogrammetric treatment in almost any in situ conditions. It’s a three steps process applied to stereoscopic pairs of digital photographs: internal orientation based on camera calibration data, relative and absolute orientations, that, in this specific case, can be trained and validated using accurate topographical survey data. These steps are completed by an automatic matching algorithm. It allows the production of a 3D grid model that can be used to orthorectify the digital picture of the grid object. The accuracy of the 3D model and the one shot recording area depend on the optical characteristics of the camera and the camera-object distance. The tests performed have produced a 0.3 mm precision model of a 1 m² area. So, the coregistered thematic (texture, color and structure that are not only defined by the shape of the object) and geometric

3. THE SOLUTIONS OFFERED BY NUMERIC IMAGE AND OPTOELECTRONIC TECHNOLOGIES

To overcome these inherent constraints of the traditional recording techniques, it is necessary to use new technologies of recording, processing and storing the data which define the precise 3D shape of any architectural object, and also the associated thematic information (texture, color and structure that are not only defined by the shape of the object...) present on a photographic acquisition of it. So the solutions to the above described problems will evidently come from the field of Archaeometry, the use of scientific laboratory techniques to investigate remains of the Past in an historical and archaeological perspective.

Figure 1. A granite false-door of Amenhotep II, as discovered in 1939 and the same in 1985

Figure 2. Aerial photograph of the West facade of the temple of Amenhotep II, taken in 1939
Almost all existing equipment for photogrammetry, digital photos, etc., are designed for contact applications and do not lend themselves to the remote measurement of the kind used for photogrammetry. This is particularly true of the kind of work done in archaeology, where there is often no opportunity to work in situ. One of the ways in which this difficulty can be circumvented is through the use of a technique known as moiré interferometry.

The moiré technique relies on the interaction between two or more periodic or quasi-periodic patterns. When these patterns are superimposed, they create a new pattern that is a moiré pattern, which can be used to extract information about the objects being measured. This is particularly useful in archaeology, where objects can be complex and difficult to measure directly.

In the case of the moiré technique, the object is illuminated with a laser, and the resulting light patterns are used to create a 3D image of the object. This technique is particularly useful in cases where the object cannot be moved, as it allows for the measurement of objects in situ. This is important in archaeology, where objects are often located in difficult to access locations.

The moiré technique has a number of advantages over other methods of 3D measurement. It is non-destructive, allowing for repeated measurements without damaging the object. It is also relatively fast, allowing for the rapid measurement of large numbers of objects. In addition, the moiré technique can be used to measure objects that are not easily accessible, making it a valuable tool for archaeologists.

In conclusion, the moiré technique is a valuable tool for archaeology and other fields where 3D measurement is required. Its non-destructive nature, speed, and ability to measure objects in situ make it an ideal choice for these applications.
moiré technique and would be complemented by a similar device based on the principles of digital (terrestrial) photogrammetry. This project is named OSIRIS (Optical Systems for Interferometric-Photogrammetric Relief Investigation and Scanning), in reference to Ancient Egypt's heritage, whose study was at the root of the above mentioned research. For the different kinds of use in the field of Archaeology and Art History, the following conditions have been defined:

- Depth resolution: 0.1 mm; lateral resolution: 0.3 mm
- Depth range: 10 cm
- Adaptation of the sensing geometry to depth gradients distribution (that will define the best compromise between acquisition resolution, focal distance and object - camera distance)
- Acquisition surface: 1 m²
- Adaptation to on site working conditions (temperature, sunlight, ...)
- Flexibility and easiness of transport and use
- Complete processing software (acquisition, multiple 3D visualisation possibilities, modeling, metrology, computer assisted interpretation, automatic features extraction, 3D database conception and constitution, ...)

Since these conditions are very demanding in comparison with the capabilities of already available 3D recording devices, other fields of application are under consideration.

The present results of the OSIRIS Project allow us to imagine for the near future new possibilities for scholarly publication of ancient monuments, i. e. in an interactive digital 3D virtual reality, directly usable for scientific researches, as if one was actually in front of the real object.

REFERENCES


ACKNOWLEDGEMENTS

It is a pleasure for us to thank the following institutions for their financial support for the OSIRIS project:
- The Communauté Française of Belgium (Action de Recherche Concertée entitled "Pour une histoire matérielle de l'Art")
- The Région Wallonne (DGTRE - First Spin Off project)

Our attendance at the Corfu Workshop was made possible thanks to the support of the Communauté Française of Belgium.

* Furthermore, Osiris is precisely the Ancient Egyptian god of periodical and cyclical phenomenon.