CIPA Heritage Documentation

The ICOMOS /ISPRS Committee for Documentation of Cultural Heritage

Le comité ICOMOS /ISPRS pour la documentation du patrimoine culturel

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INTERNATIONAL SOCIETY FOR PHOTOGRAMMETRY AND REMOTE SENSING
INTERNATIONALE GESELLSCHAFT FÜR PHOTOGRAMMETRIE UND FERNERKUNDUNG
SOCIÉTÉ INTERNATIONALE DE PHOTOGRAMMÉTRIE ET DE TÉLÉDÉTECTION

International Council on Monuments and Sites

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PROCEEDINGS OF THE CIPA WG 6 INTERNATIONAL WORKSHOP ON

SCANNING FOR CULTURAL HERITAGE RECORDING

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PREFACE

Scanning instruments, recording hundreds or even thousands of 3D points per second, have added a new perspective to metric surveying. Besides topographic laser scanners operating from airplanes, various instruments are available for close range applications.

Although all of those instruments produce 3D coordinates in real time, they rely on different principles. Ranging instruments can be explained as high speed surveying instruments whereas triangulation type instruments, including one or two digital cameras, could be regarded as photogrammetric devices. From a user's point of view, a discussion whether scanners belong to geodesy or photogrammetry is of no relevance, however.

So far, scanners were widely used for the as-built-documentation in industry. The rapid measurement of huge numbers of 3D points on object surfaces is also very suitable for the documentation of cultural heritage objects, such as buildings, ruins, sculptures and artifacts. The CIPA Symposium in September 2001 at Potsdam, Germany, showed that scanner producers are interested to enter this market and some users have already gained first experiences with this new metric recording technique. Preservation authorities in several countries have asked for guidelines concerning the use of scanning techno-logy, especially in comparison with close range photogrammetry.

This was the motivation for CIPA Working Group 6, "Surveying Methods for Heritage Recorders", to offer this two day workshop "Scanning for Cultural Heritage Recording – Complementing or Replacing Photogrammetry" immediately prior to the ISPRS Commission V Symposium at Corfu, Greece. The great response from authors and participants confirms the acute interest in this subject. The papers in this volume prove that in many cases both, scanning and photogrammetry can be used advantageously within one documentation project. Which method should be used to what extent under given pre-requisites cannot be answered definitely yet. May the presentations and the discussions of this workshop lead to a clearer view of this question, thus serving the documentation of our cultural heritage.

I would like to express my deepest gratitude to Petros Patias, President of ISPRS Commission V, from the Aristotle University of Thessaloniki, Greece, and his team who took over all the organizing tasks for this workshop from the announcement in the WEB to the printing of the proceedings. This made it easy for myself and my assistant, Mirko Siebold, to organize the scientific program and to edit this volume at the Institute for Spatial Information and Surveying Technology (i3mainz) at FH Mainz, University of Applied Sciences, Germany.

I sincerely hope that all participants will appreciate the program, have the opportunity to meet old and new friends and find some time to enjoy beautiful Corfu Island.

Welcome to the Workshop!

Prof. Dr. ***Wolfgang Boehler***
Chairman CIPA WG 6

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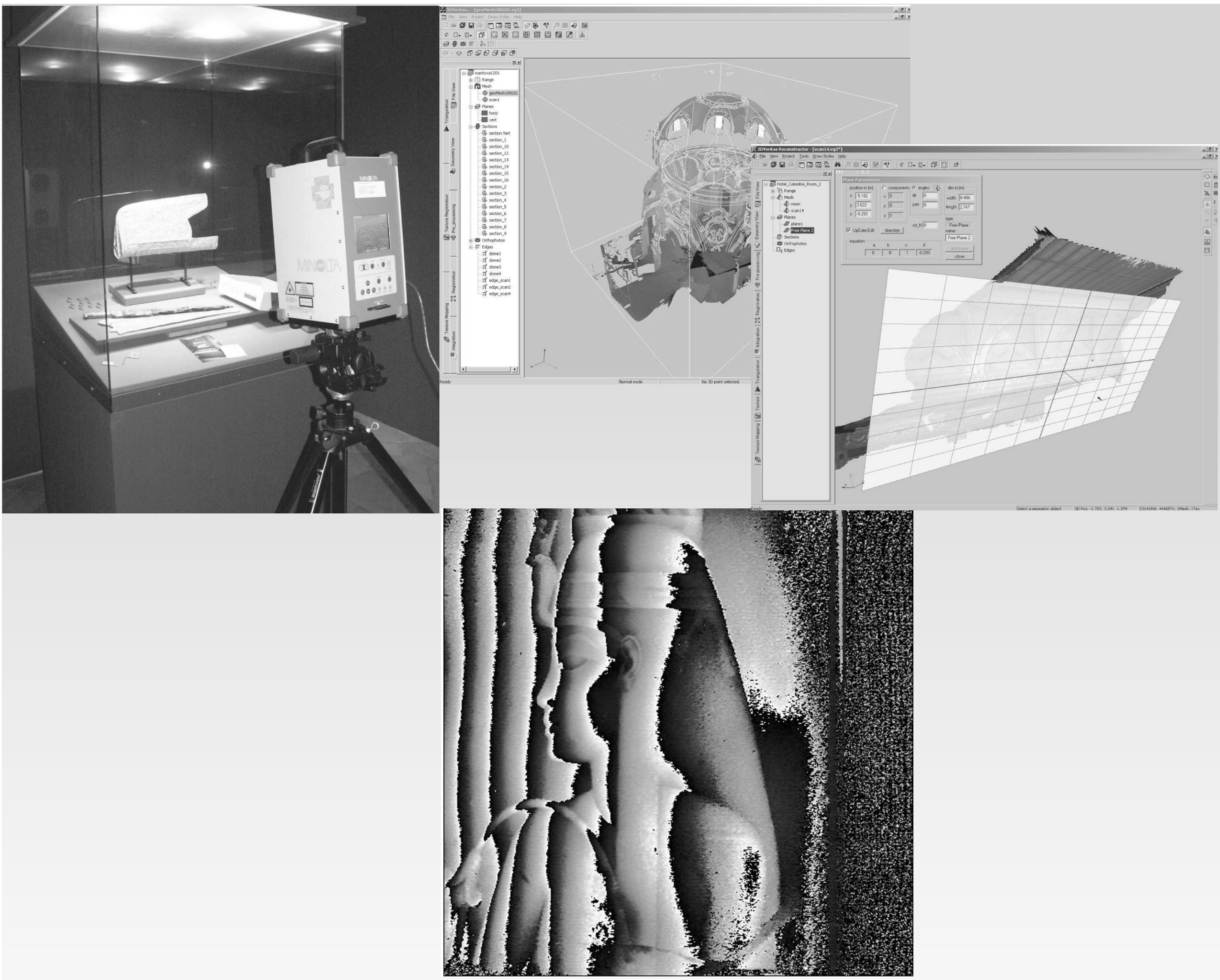
VARIOUS SUBJECTS



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

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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 archaeological 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).

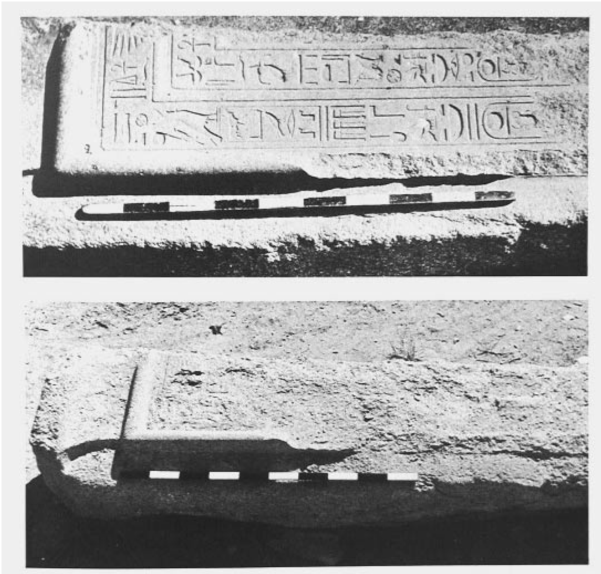

Figure 1. A granite false-door of Amenhotep II, as discovered in 1939 and the same in 1985

To counter this progressive and irremediable annihilation of the material remains of the Past, Archaeology uses different recording techniques. Contrary to a quite general opinion, photography cannot ideally fulfil the purposes of the recordings needed by Archaeology and Art History: it always privileges one single plane of view, reducing the volume of the objects to a 2D picture; thus, it often introduces some distortions (mainly optical ones); it does not allow interpretative notation which might help its reading; and, finally, the results of traditional photography fade with time (silver halide emulsion, slide and paper copy). Therefore Archaeologists and Art Historians usually rely upon different complementing techniques of recording by drawing, but all these graphic techniques have a common rather poor flexibility in their management and their set up, and, also, an unavoidable dependence on the subjectivity of reading and rendering of a human operator (Traunecker, 1987; Loeben, 1996). In order to preserve a minimum of accurateness, these drawing recordings are usually very slow,- and thus very expensive,- a fact that gives rise to a real race against time and the damages it can cause to historical monuments exposed to modern pollution (physico-chemical and tourist pollution). So recording in Archaeology and Art History raises two essential problems, related one to the other: on the one hand, the objectivity, and on the other, the speediness and the flexibility of realisation.

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 archaeological 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.

Nowadays, numeric image technology offers an almost infinite flexibility of use, with which traditionnal 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 Geomatics of the University of Liège (notably in the SURFACES Laboratory [Service Universitaire de Recherches Fondamentales et Appliquées en Cartographie et Étude Spatiales ; dir. Pr J.-P. Donnay], in close cooperation with the ICAUL [Interdisciplinary Center for Archaeometry of the University of Liège; 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 unable 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 stereographic 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 sensed 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 $1 m^2$ area. So, the coregistred thematical (texture, color and structure that are not only defined by the shape of the object) and geometric characteristics of the objects can be used for further analogical or numerical computer assisted interpretation and automatic features extraction. But no such device is already available now.

The other principle that allows optical or optoelectronic 3D recording of archaeological objects is the triangulation, *i. e.* the fact that the distance between a point and an observer can be determined through the change of position caused by this point to a laterally projected light pencil. This principle is used in many relief analysis techniques, among which the very well-known linear scanning method.

The linear scanning method can be summarised as follows: a laser line is projected on the studied object and appears distorted by the relief of this object when it is seen with an angle from the incident direction. By scanning the object surface with an accurate positioning system, it is possible to get the depth information line by line and then to reconstruct a 3D representation of the object. This technique may only examine one scan at a time. So it is limited by the accuracy of the positioning system and the way to create the scanning line. Many tests have revealed that, because of this limitation, it is very difficult (and sometimes impossible) to use a laser scanning system with high precision in aggressive environmental conditions like those found in many archaeological sites. The possible applications in the field of Archaeology are thus limited.

The main problem of the scanning method, that is the problem of moving precisely the scanning laser line, can be eliminated by generalising the triangulation principle: instead of one single line, it is a constructed pattern or a grid that is projected. Its deformation is then used as the probe of the relief. This light pattern has to be periodically structured and static, based on a grid alternatively light and dark. One projects it on the surface to analyse. By recording the scene with a CCD camera, it is possible to superpose the image of the grating modified by the relief with the reference one without any deformation. This process, which replace the comparison between the distorted laser line and the original one, creates geometrical shapes (Figure 2); it is the moiré effect, whose fringes pattern is closely connected with the relief of the analysed object. Everyone has already seen this effect, often ignoring it: when somebody on television wears a striped or squared clothe, this pattern, modified by the anatomy of the person itself, interferes with the pixels grid of the camera and generates a moiré effect. The interpretation of these moiré pictures through the triangulation principle gives the whole relief information of the analysed object (Figure 3). The accuracy of this technique is comparable with the accuracy of the traditional laser scanning but its process is much more faster, since a surface of one square meter can be analysed in one time, with a single shot. Besides, the elimination of the problems linked to the precise and regular moving of the laser line makes it much easier to use in difficult *in situ* conditions. So the moiré technique perfectly fulfil the requirements of archaeological recording: fast acquisition, accuracy, robustness and flexibility, necessary to allow working on site, in aggressive environmental conditions. Moreover, by combining moiré and photogrammetric approaches, it is possible to define the recorded 2.5 surface shape in an euclidian cartesian reference system that allows metrology and merging thematic and geometric information from the object in this system.

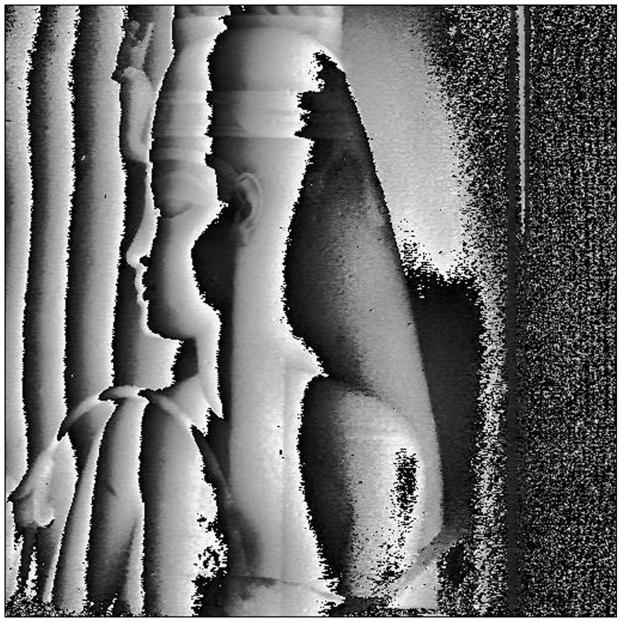

Figure 2. Moiré effect on an Ancient Egyptian Relief (copy of the relief Brussels MRAH E 2157)

Figure 3. Detail of a 3D recording of the same relief with the projected moiré technique

5. CONCLUSION: THE AIMS OF THE OSIRIS PROJECT

In conclusion of all this, the ICAUL (Interdisciplinary Center for Archaeometry of the University of Liège), with Hololab Laboratory and SURFACES (Service Universitaire de Recherches Fondamentales et Appliquées en Cartographie et Étude Spatiales) Laboratory, of the University of Liège, have decided to develop together a complete portable set-up (making the whole optoelectronic acquisition and the data processing) specifically dedicated to the quick and accurate numerical 3D recording of archaeological documents. It will use the projected 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 researches*. 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 m^2
- 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.

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- 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.

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CIPA: The ICOMOS & ISPRS Committee for Documentation of Cultural Heritage

is one of the oldest international scientific committees of ICOMOS (International Council on Monuments and Sites), established in collaboration with ISPRS (International Society of Photogrammetry and Remote Sensing).

Its main purpose is the improvement of all methods for surveying of cultural monuments and sites, specially by synergy effects gained by the combination of methods under special consideration of photogrammetry with all its aspects, as an important contribution to recording and perceptual monitoring of cultural heritage, to preservation and restoration of any valuable architectural or other cultural monument, object or site, as a support to architectural, archaeological and other art-historical research.

ISPRS and ICOMOS created CIPA (1969-2001: Comité international de la photogrammétrie architecturale) because they both believe that a monument can be restored and protected only when it has been fully measured and documented and when its development has been documented again and again, i.e. monitored, also with respect to its environment, and stored in proper heritage information and management systems. In order to accomplish this mission, CIPA will:

- establish links between architects, historians, archaeologists, conservationists, inventory experts and specialists in photogrammetry and remote sensing, building surveying, spatial information systems, CAAD, computer graphics and other related fields (Framework of CIPA Links);
- organise and encourage the dissemination and exchange of ideas, knowledge, experience and the results of research and development (CIPA Expert Groups and CIPA Mailing List);
- establish contacts with and between the relevant institutions and companies which specialise in the execution of photogrammetric surveys or in the manufacture of appropriate systems and instruments (Board of Sustaining Members);
- initiate and organise conferences, symposia, specialised colloquia, workshops, tutorials, practical sessions and specialised courses (CIPA Events);
- initiate and co-ordinate applied research and development activities (CIPA Working and Task Groups);
- undertake the role of scientific and technical expert for specific projects (CIPA Expert Advisory Board);
- organise a network of National and Committee Delegates (CIPA Board of Delegates);
- submit an annual report on its activities to the ICOMOS Bureau (Secretary General) and the ISPRS Council (Secretary General) and publish it in the internet (Annual Reports);
- publish also its Structure, its Statutes and Guidelines in the internet (CIPA web pages).

CIPA experts groups and working fields:

Applications: A1 - Recording, Documentation and Information Management - Principles and Practices; A2 - Architectural and Industrial Conservation; A3 - Archaeological Conservation, Geophysical prospection, Underwater Heritage and Museum Objects; A4 -Urban and Landscape Conservation; A5 - Risk Preparedness

Techniques: T1 - Photogrammetry and Remote Sensing; T2 - Building Surveying ; T3 - CAD/CAAD (Computer Aided Architectural Design); T4 – Heritage Information Systems; T5 - Visualization and Virtual Reality

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CIPA: The ICOMOS & ISPRS Committee for Documentation of Cultural Heritage

CIPA est l'un des plus anciens comités scientifiques d'ICOMOS (le Conseil International des Monuments et des Sites) établi en collaboration avec l'ISPRS (la Société Internationale de Photogrammétrie et de Télédétection).

Son but principal est l'amélioration des méthodes de relevé et de documentation des monuments et sites historiques, plus particulièrement en profitant des synergies issues de la combinaison des méthodes considérant tous les aspects de la photogrammétrie. Les travaux du CIPA sont une contribution importante à la sauvegarde du patrimoine culturel et architectural, à la conservation et la restauration des monuments, objets et sites, et une aide à la recherche en architecture, en archéologie et en histoire de l'art.

ISPRS et ICOMOS ont créé le CIPA (1969-2001 : Comité International de Photogrammétrie Architecturale) avec la conviction qu'un monument peut être reconstitué et protégé uniquement lorsqu'il a été entièrement relevé et documenté, et quand ses changements ont été régulièrement enregistrés. Un monument surveillé et prenant en compte son environnement peut être géré dans un système d'information patrimonial.

Afin d'accomplir cette mission, le rôle du CIPA est :

- d'établir des liens entre les architectes, les historiens, les archéologues, les spécialistes de la conservation, les experts du relevé et spécialistes en photogrammétrie et télédétection, en relevé des constructions, en systèmes d'information spatiale, en conception assistée par ordinateur, en infographie et dans d'autres domaines concernés (par l'intermédiaire de la structure des liens du CIPA);
- d'organiser et d'encourager la diffusion et l'échange d'idées, de connaissances, d'expériences et de résultats de recherches et de développements (par les groupes d'experts du CIPA et par la liste de diffusion du CIPA);
- d'établir des contacts avec et entre les organismes et les sociétés spécialisées dans l'exécution des relevés photogrammétriques ou dans la conception de systèmes et d'instruments spécifiques (par l'intermédiaire du Conseil des membres de soutien);
- d'initier et d'organiser des conférences, des colloques spécialisés, des ateliers, des formations, des sessions pratiques et des cours spécialisés (dans le cadre des évènements du CIPA);
- d'initier et de coordonner la recherche appliquée et le développement des activités (par les groupes de travail du CIPA);
- d'entreprendre le rôle d'expert scientifique et technique pour des projets spécifiques (par l'intermédiaire du comité consultatif des experts du CIPA);
- d'organiser un réseau de délégués nationaux et de délégués du Comité (regroupés dans un conseil des délégués du CIPA);
- de soumettre un rapport annuel sur ses activités au bureau d'ICOMOS et au Conseil de l'ISPRS (par le Secrétaire Général) et de le publier sur internet;
- de publier également sa structure, ses statuts et directives sur le site internet du CIPA.

Groupes d'experts du CIPA et champs d'investigation :

Applications: A1 : Principe et pratique de l'enregistrement, de la documentation et de la gestion de l'information; A2 : Conservation architecturale et industrielle; A3 : Conservation archéologique, prospection géophysique, patrimoine sous-marin et objets de musées; A4 : Paysages culturels et urbains; A5 : Prévention du risque

Techniques : T1 : Photogrammétrie et télédétection; T2 : Relevé des constructions;T3 : Conception Architecturale Assistée par ordinateur; T4 : Systèmes d'information pour le patrimoine culturel; T5 : Visualisation et réalité virtuelle