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COMPUTER AIDED GRAPHICAL DOCUMENTATION IN ARCHAEOLOGY

Documentation of an excavation today is still one of the most important requirements for many researchers who investigate the past.

Since the time of the excavation of Troy, the combination of Schliemann's enthusiasm with Dörpfeld's precision, clarity, sound method, and sobriety made a genuinely scientific contribution to the understanding of the history of Troy possible.

The question of the correct documentation of each archaeological excavation persists, not only because necessities often are missing due to low budgets, but also because some excavators have not yet become aware that documentation (graphical, photographical etc.) and excavation should not be separated.

Some excavations still take place without participation of an architect or draftsman.

The technological progress of photogrammetric applications (which usually can be employed with difficulty by non-specialists) offers more and more possibilities for a quick and easy solution to the relative questions such as the survey. However, all these new products require special training which sometimes is very time consuming. Nevertheless, evolution of computer software products is advancing so quickly that there is always something better and more up-to-date to offer[1].

Although there are enormous advantages in using photogrammetric methods to survey archaeological excavations and sites, the presence of specialized personnel is necessary and this results in an increase of the budget for the excavation. Another negative factor is that the final product, which can be of a high precision from a geometrical point of view, usually is not easy to understand or of value to the final user. Technological advances in this field have produced more simple computer hardware and more user-friendly software, but when the non specialist tries to use them, the results are not always satisfactory[2].

[1] In recent years, small analytical photogrammetric systems have been introduced. Some of them like Elcovision (Leica), RolleiMetric MR2, Fotomass, Foto3d, Photocad, etc are using metric or non metric cameras. The coordinates of the pictures are introduced into the computer through a digitizer. Also more advanced systems, comparable with the very good analytical photogrammetric systems, are the small and much more cheaper digital photogrametric systems like Eos Photomodeler, Leica DVP, Phidias, VTA-VMAP, etc in which the 3d observation at the monitors screen can be very useful. Most of the above systems are dedicated to architectural and monument conservation applications but they can be used very easily for excavation application if our pictures are from a low height.

[2] In this group we can include the specialized rectification software products which are based on personal computers. They can be used mainly for architectural or archaeological documentation. Some of these systems are: Archis (Galileo Siscam), Leica DVR2, DIRECT

On the other hand, it is necessary to recognize the possibilities offered by computers with their high speed calculations, and photographs (containing infinite information) as a metric tool. A simple combination of these two, applied in several excavations in Greece, gave very satisfactory results[3]. The method was based on photographs which were taken from a low altitude (5 meters) and which covered an archaeological site. These pictures could then be used as a photomosaic giving a detailed overall view of the site due to the low scale e.g. 1:20-1:50, but also separately by digitizing them through a digitizing tablet.

For the low altitude photographs a simple monopod construction was used consisting of a telescopic tube (Fig. 1). At the highest point of the tube a camera was attached with an automatic system for horizontal leveling. A small non metric camera with automatic forward winding of the film was used. The height of the camera was controlled by a thin transparent cord which also gave the projection of the camera to the ground. To advance the film, a pneumatic control was used. The area covered by each picture was easily determined in advance on the basis of the focal length of the lens of the camera and the height of the camera from the ground[4]. Due to the low weight of the system, it was easy for the operator to move to all points of the excavation and to cover the whole area with vertical pictures.

If reference points (at least four) with well-known coordinates appear in these pictures, it is possible to enter them into a computer and to manipulate the rest of the points covered by the photograph graphically. The reference points can be preset on the site with small marks (Tav. XV, a). It is necessary to calculate their coordinates very carefully. This is done either with direct measurements (if the points are few) or with the use of a Total Station. The manipulation of this data through a least square adjustment software program makes a more accurate determination of the points possible.

By processing these points through a digitizing tablet in our computer, we can calibrate every picture and thus obtain xy information for any other point of the objects that appears in the picture. The rectification of the central perspective projection of every picture can be done using well known cad

(Un. of Thessaloniki) etc. This article is based mainly on simple rectification applications provided from the ACADR12.The photogrammetric process of rectification through software is based on the calculation of the azimuth of the rotation and the value of the tilt. Eight coordinates of at least four reference points are measured using the principal point as the origin and the sides of the photograph as the X and Y axis.

[3] The method was used for the excavations at the site of *Abdera* (city and port) in north Greece, the excavation of the prehistoric site of Dikili-Tas, at the underwater installations of Toroni, at the "Alonisos" and "La Thérèse" shipwrecks and at the Bertseko's mine washers at Lavrion-Attica.

[4] The required height can be calculated once the orientation of the camera format to the baseline has been determined. Assuming that the long (36 mm) side of the frame is at right angles to the axis of the site, then if D is the line separation and d is the length of the graduations, then the height H is given by: $H = (20 \times D/36)$.

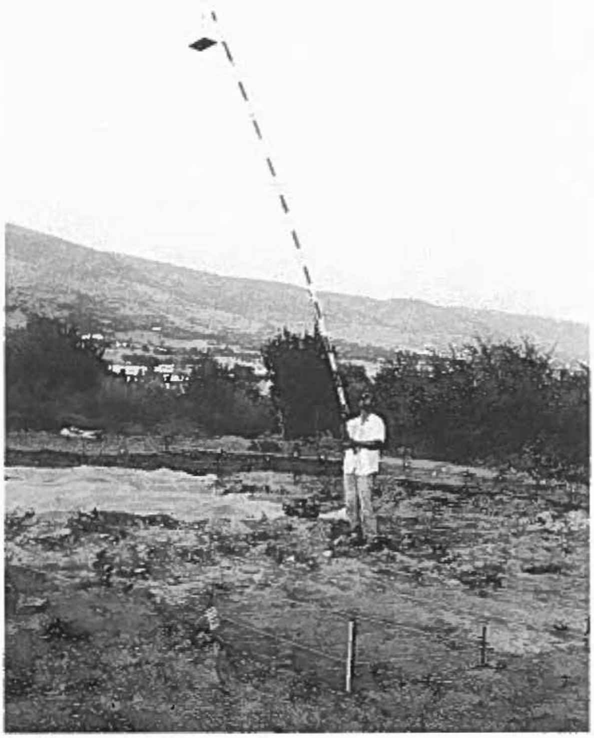

Fig. 1 – A simple monopod construction with a telescopic plastic tube and an automatic system for horizontal liveling.

software programs, but also in its simplest form, the Autocad ver.>12 software. At the same time using the drawing commands of such a program we can trace exact contours of each feature that appears in the picture.

Because this method is more accurate when we are working in flat areas, when the area presents a high relief, it is necessary to use reference points on the same level for the calibration of the digitizing tablet.

The whole job at the site will usually take a few hours and a picture that was shot e.g. from a height of 5 meters will cover approximately an area of 5×3 meters (with a 38 mm lens). The coverage of the area with low altitude pictures permits us to observe all the objects and their details with high resolution and also in 3d. If in some areas we need more detail, this can be obtained by fixing the telescopic tube at a lower point.The construction of a monopod with a telescopic tube is very simple and in publications related to the subject there are a lot of examples[5].

[5] A number of archaeologists have felt the need to take vertical views of their sites

Fig. 2 – An example of a shallon water archaeological site photographed with a monopod from a low height (500 m). Archaeological site of Torone in Chalcidica – Greece.

The above method of analytical rectification was also used with very good results for the documentation of underwater constructions such as ports, cities etc. In this case, due to the shallow water in which we find constructions, it is very easy to measure the reference points from the land. In cases like this, the shooting of pictures above the sea can be done in the same way as on land. Best results are obtained when the sea is calm (Fig. 2).

In the case of shipwrecks, where the depth is greater, vertical shooting is extremely easy because the diver-operator can precisely control his height and position himself for each shot by inflating or deflating his jacket (Fig. 3). The horizontal level of the camera can be controlled with a little bull's eye level at the back of the camera (Fig. 4). The measurement of the underwater reference points is more difficult than those on land. One way is to take direct measurements and to calculate the depth of each point with a precise depthmeter. Another easier way is to use a metric table and to calculate the points in a graphic way using for example an underwater theodolite (Fig. 5). A system with good precision is the "SHARPS" which uses an acoustic beam

during the excavation. Huge ladders are sometimes available as well as special platforms. One of the early applications was proposed by G.T. Schwarz (Schwarz 1966), with the use of a monopod construction which was able to take low altitude pictures but not vertical. Very useful remains the book of J.H. Whittlesey (1979), which describes the use of a bipod camera support to hold a camera vertically oriented over an archaeological site. A Swedish team of archaeologists developed a giant tripod 14 m. high, mounted by a half dozen people! (Blomè 1963). The simple monopod used by the author has no restriction of time (one might not keep platforms etc. indefinitely on the site) and space (many sites do not offer access to heavy equipment, especially when the work is near completion and sections have been dug all over the place), and can be carried by a single operator at any point of the excavation for a vertical shooting.

Fig. 3 – An example of shipwreck vertical shooting. The diver-operator can precisely regulate his height inflating or deflating his jacket (A). The horizontal level of the camera can be controlled with a bull'eye level (B) (from the "La Thérèse" shipwreck, Herakleion Crete).

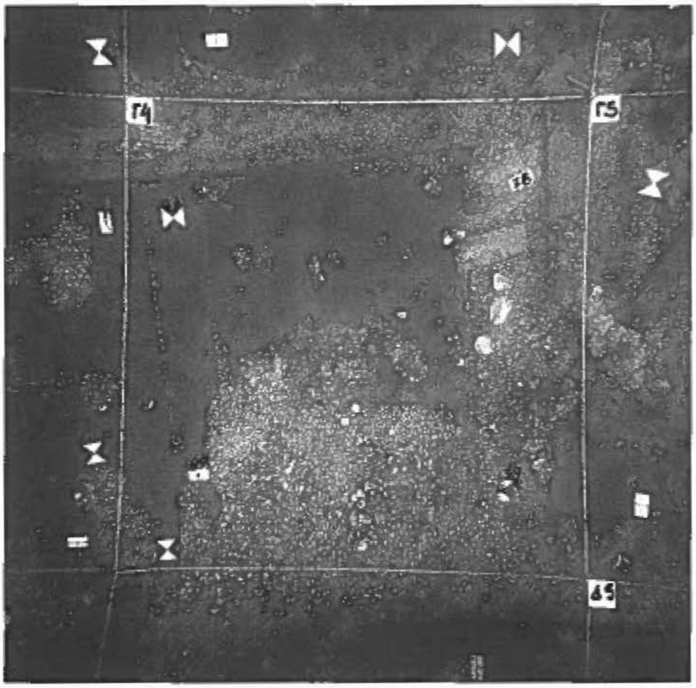

Fig. 4 – The "La Thérèse" shipwreck. An example of vertical shooting using a HASSELBLAD camera in an underwater housing.


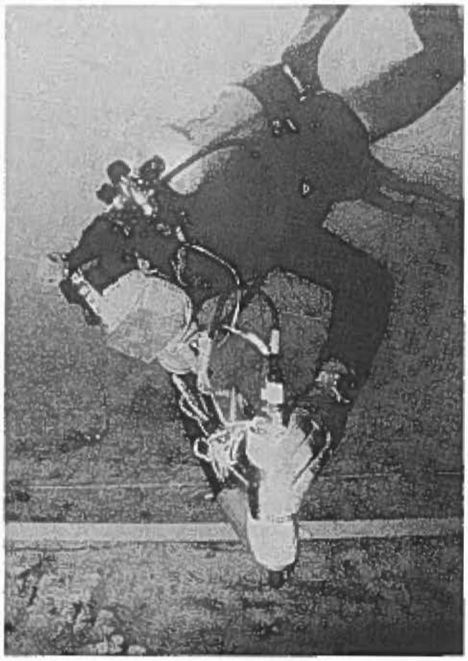

Fig. 5 – An example using an underwater theodolite (from GREEN 1990).
Fig. 6 – Using SHARPS system for the calculation of x, y, z coordinates of the reference points (from the Dhokos Is. shipwreck).

u/w that is calibrated at the surface with the use of a computer[6]. It is an expensive method and needs specialized operators (Fig. 6).

During research at the Alonissos (Peristera) shipwreck (HADJIDAKI 1992, 16-25) (Fig. 7), two methods of survey were used. The first method was based on a simple analytical rectification software program produced by the Department of Marine Archaeology on Autocad 11 platform program (author of the software program is Dr. M. Marder). The second method used a photogrammetric station (KARANTAIDIS 1992). Both methods gave good results (at least from an archaeological point of view) regarding the accuracy and the speed of survey which in underwater cases is very important[7]. The precision of the survey obviously depends on the accuracy of the measurement of the reference points which, as it was mention before, it is difficult for underwater sites (Fig. 8). The first method needs only a portable computer

[6] SHARPS (Sonic High Accuracy Ranging and Positioning System) is an echo system for fixing the three-dimensional position of a point. The system consists basically of four transmitter-receivers, a control unit and a computer. Three of the transmitter-receivers are set on the seabed to form a triangle. The fourth, transmits sound pulses as it is moving by the diver to the different points to be measured. See also KYRIAKOPOULOU 1990.

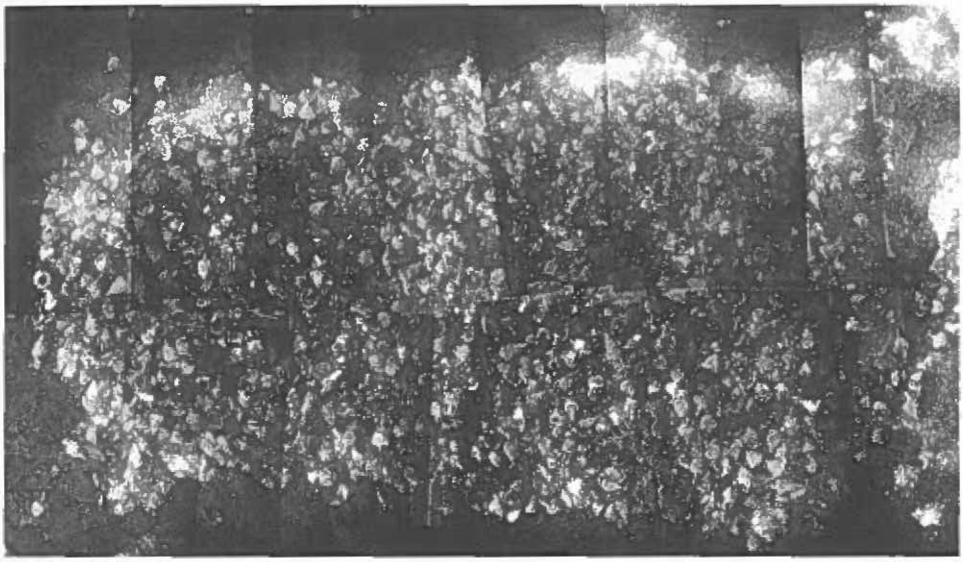

Fig. 7 – The "Alonisos" shipwreck (courtesy E. Hadjidaki).

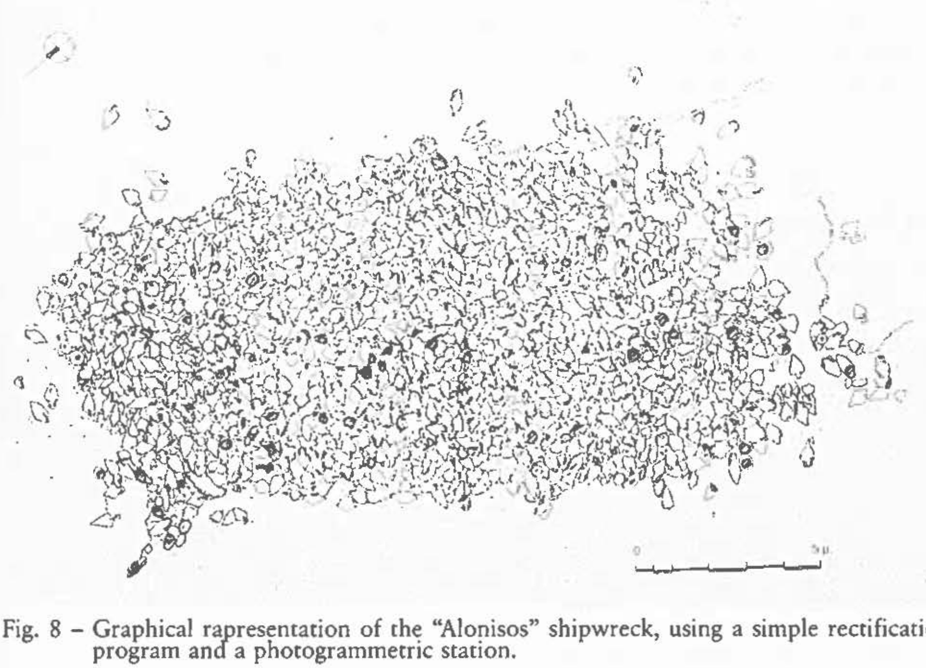

Fig. 8 – Graphical rapresentation of the "Alonisos" shipwreck, using a simple rectification program and a photogrammetric station.

and a ditigizer. Thus it allows one to carry out the whole project at the site and follow the process of the excavation day by day. The second method needs fewer reference points. In both systems non metric cameras were used.

At the "La Thérèse" shipwreck (1994), the least square adjustment calculation of the reference points and their rectification was processed by using only the routines of the ACADR12. The method which is demonstrated (Fig. 8) here is extremely easy to use by persons with no previous computer or ACAD experience[8].

At the same shipwreck also a small digital photogrametric system VTA-VMAP was used[9]. Obviously, stereoscopic reduction of the image by means of an optical system allowing full image display on the monitor allows wider quantitative possibilities[10]. The measuring process of the small digital photogrammetric systems is basically similar with that of the digital photogrammetric stations. The use of the system on the site of excavation and the continuous follow up of the excavation is very important, but the presence of specialized users in the field is necessary in both methods.

In conclusion, for a quick and high precision survey, a simple rectification software program used on a low cost hardware (e.g. a 386/40 PC and with a 12×12 "digitizer"), combined with low altitude pictures, should be among the standard equipment of every excavation. This method can provide a documentation of high accuracy of every archaeological stratum and also details of all the findings.

For more precision in much higher budget excavations, a small digital photogrammetric system can be used on the site or a digital photogrammetric station at a latter stages.

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BIBLIOGRAPHY

BLOMÈ B. 1963, *Die Rollei in der Archaeologie*, «Rollei-Journal».
HADJIDAKI E. 1992, *Anaskafi se klassiko nayagio sten Alonisso*, «Enalia», 4, 1/2, 16-25.

[7] According to the diving tables, at the "Alonissos" shipwreck the zero time for each diver was 20 minutes. At the "La Thérèse" shipwreck, 55minutes.

[8] According to the routines of ACAD 12, first we have to calibrate our digitizing table, digitizing the reference points of our picture (at least four points but the program can accept up to 32). Then choose the perspective projection. If we already have a *.dwg file opened with all the coordinates of our site, the area of each picture will automatically be set at its exact position.

[9] VTA-Vmap belongs to the class of the small digital systems. It has the possibility to use all kinds of digital pictures independently from their geometry; it combines the characteristics of a fotogrammetric instrument with the possibilities of a graphic station, can provide graphical or digital products and has the possibility for an automatic process of all the photogrammetric routines.

[10] Like 3d calculation which is extremely useful e.g. for the shipwreck crossections and generally for accurate 3d survey.

GREEN G. 1990, *Maritime Archaeology*, Academic Press.

KARANTAIDIS D. 1992, *Ypovrychies Fotogrammetrikes Apotyposis*, «Epigia fotogrammetria...», Thessaloniki, Un. Aristoteleion of Thessaloniki, 213-221.

KYRIAKOPOULOU V. 1990, *Underwater surveying with the Sharps in the 1989 excavation season at Dhokos*, «Enalia», 1, 24-26.

MACKENDRICK P. 1962, *The Greek Stones Speak*, New York, Mentor-New American Library, 22.

SCHWARZ G.T. 1966, *Stereoscopic views taken with an ordinary single camera*, «Archaeometry», 36-42.

WHITTLESEY J.H. 1979, in D.L. CLARK JR. (ed.) *Photogrammetry for Archaeology*, New York.

ABSTRACT

This paper deals with the advantages of simple photogrammetry methods used in the documentation of the archaeological excavations. The proposed method is based on low altitude vertical pictures, a Least Square Adjustment calculation software program and a common CAD software. Description of the method and different applications are also included.