

FAST AND ACCURATE DOCUMENTATION OF ARCHAEOLOGICAL SITES USING IN THE FIELD PHOTOGRAMMETRIC TECHNIQUES

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ABSTRACT

In the last few years, digital photogrammetry became a major tool in archaeology. Specialists in this area recognize the advantage of fast and accurate mapping. Moreover they use photogrammetric techniques in order to record and document the findings of an archaeological site or the whole excavation. Mainly in prehistoric sites, there are several different temporal levels of ruins and very often the site has been constructed upon other ancient or prehistoric cities (different levels).

It is very important for the archaeological research to record, map and monitor all the different levels of an excavation accurately. Alongside, time is a valuable factor for the archaeologists who can not rely upon the time consuming mapping of the excavation with the traditional way. Digital photogrammetry gives to the archaeological research all the powerful tools for an accurate mapping and recording of the archaeological sites.

The specific interdisciplinary experimental research took place in an archaeological site of an ancient city of Eleftherna in Crete, Greece. Particularly, the excavation holes have been photographed and processed at three different stages (days) of the excavation progress. DTM and orthophotos for each hole have been created in all different stages. Additionally, digital images have been acquired for small artifacts that were found during the excavation process and their 3D models have been created.

1. INTRODUCTION

In the last few years, digital photogrammetry became a major tool in archaeology. Specialists in this area recognize the advantage of fast and accurate mapping. Moreover they use photogrammetric techniques in order to record and document the findings of an archaeological site or the whole excavation (Grussenmeyer & Perdrizet, 1996).

In some archaeological sites, there are several different temporal levels of ruins. These sites are mainly prehistoric. In the majority of such cases, the site has been constructed upon other ancient or prehistoric cities. Nowadays, the excavation progress does not stop until all the different levels of findings –coming from different chronological periods- reach the daylight. Therefore it is very important for the archaeological research to record and map all the different levels of an excavation accurately. Digital photogrammetry gives to the archaeological research all the powerful tools for a fast and accurate recording and mapping of the archaeological sites. The new low cost digital cameras, providing high resolution images, in combination with the new user-friendly small and portable photogrammetric systems, constitute powerful tools, certainly for the whole mapping process in the period of a day. This is very important because the archaeological image interpretation is performed in the same day. Especially nowadays, digital images can be pre-processed either on the site using a notebook or in an office based on internet. In order to take the internet advantages, image acquisition can be done by the archaeologist in the site and photogrammetric process somewhere else. The final products are feed back to the site for the interpretation.

The specific experimental research took place in an archaeological site of the ancient city of Eleftherna in Crete, Greece. The test introduced a productive collaboration between photogrammetrists and archaeologists for the recording and mapping on the field several parts of the excavation. The whole program was introduced as field project for the postgraduate students. Particularly, the excavation hole have been photographed and processed at three different stages (days) of the excavation progress. DTM and orthophotos for each hole have been created in all different stages. At the first stage, control points were set by typical surveying methods. Due to the excavation progress, the control points were destroyed, and therefore at a second or third stage «new control points» were produced from photogrammetric measurements of first the stage data. In order to check the produced DTM, enough check points have been collected

with the typical topographic techniques. Additionally, digital images have been acquired for small artifacts that were found during the excavation process and their 3D models have been created.

2. THE NETWORK ESTABLISHMENT – TOPOGRAPHIC MEASUREMENTS



Figure 1. Topographic Network in the archaeological site



Figure 2. Control Points Network

A topographical network of points has been established in the archaeological site consisting of 10 stable points. In Figure 1 a part of this network is presented.

All topographic network points have been measured just once, at the beginning of the archaeological excavation period. Alongside the network points, control points in the excavation holes (Figure 2) have been measured as well. The accuracy, both for topographic and control points, has been estimated to better than 1cm.

3. PHOTOGRAMMETRIC PROCESS

Photogrammetric process has been split in two steps, the one which is related to the mapping of excavation holes and the one which concerns the modeling of small artifacts, found during the excavation process, emphasizing for fast photogrammetric mapping. The target was the production of a 5mm pixel size orthophoto until early in the afternoon so as the interpretation process could be done in the rest of the day. In order to achieve this, the image acquisition have been done early in the morning. For artifacts mapping no daily restrictions have been set.

3.1 Mapping of the excavation holes

While a few excavation holes were at the archaeological site, a specific one (4m x 4m) has been selected for mapping due to its particularity. At the first day the top level of the excavation hole was the natural ground surface. In the next day the depth of the hole reached 2m and finally the last day only a few excavation work was done, mostly cleaning and preparing the hole for mapping.



Image size: 1024x768

Pixel size: 4.7 μm

Figure 3. Sony Mavica FD81

For image acquisition a digital camera Sony Mavica FD81 has been used (Figure 3), giving the opportunity to check for the quality of the images at the field. The image processing as well as the photogrammetric process took place in a temporary laboratory near the excavation site. The images were acquired early in the morning where the sunlight is not so heavy and the images have high color texture. Additionally, it has been set as a time restriction that early in the afternoon the final product (orthophoto) must be ready for in the field archaeological interpretation.

More than two overlapping images were required for the total stereoscopic image covering of the excavation holes (usually four images were enough) from two or more different camera stations.

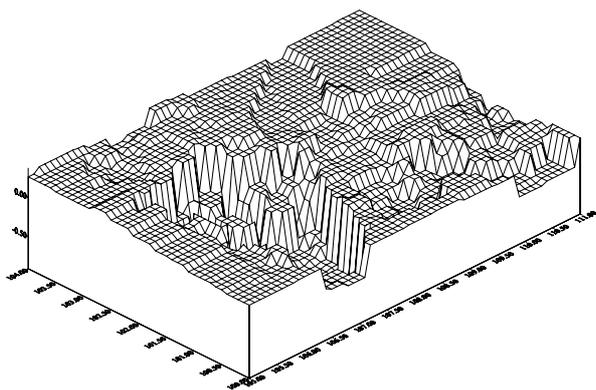


Figure 4. DTM generated with topographic methods

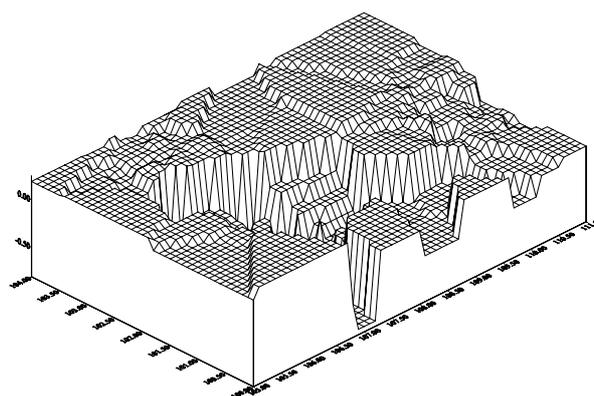


Figure 5. DTM generated with photogrammetric methods

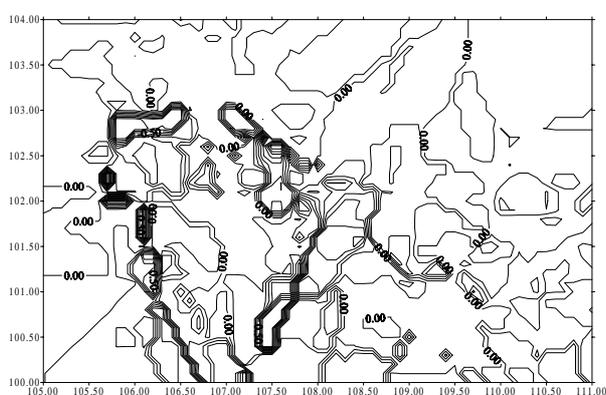


Figure 6. Difference DTM in contour presentation

Using the ground control points, a bundle adjustment process was performed both for the exterior orientation calculation and for the establishment of «new control points». These «new control points» were selected in geometrically specific and stable positions to be used in the next stage. The bundle adjustment accuracy (RMS) was 1cm.

As soon as the exterior orientation was produced, detail and interesting points were manually collected in all the images and their ground coordinates were calculated as well. These intersection points were used for the DTM production (Figure 5). DTM has been also collected with topographic methods (Figure 4). The two DTM's seems to be very close to each other. In Figure 6, the difference of the two DTM's (in contours) is presented and as it can be seen for 95% of

the model the difference range is 0cm to 5cm and only in 4 very small areas the range is 0cm to 50cm. This is due to the fact that detail points, were impossible to be collected in the photogrammetric process. Better image acquisition can be done with useful structures, such as a movable scaffold or a telescopic arm (Miyatsuka, 1996).

An orthophoto for each one of the four images –covering the excavation hole- has been created and finally all the registered images were joined to create an orthophoto mosaic (Figure 7).

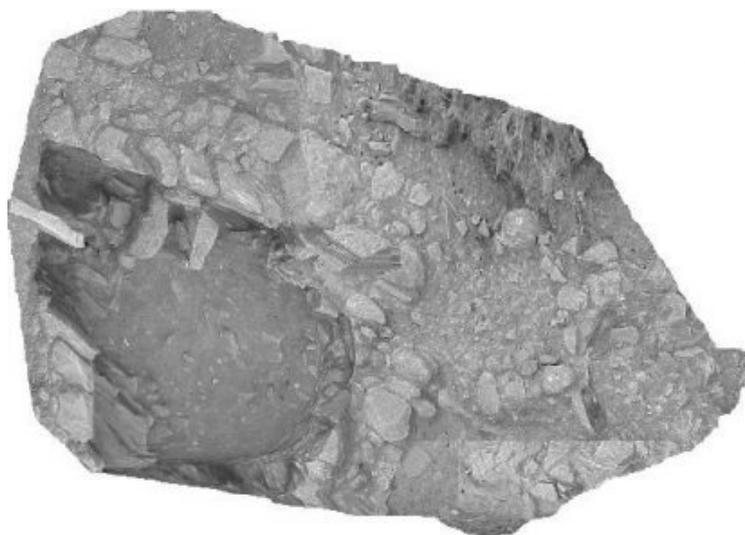


Figure 7. Orthophoto of an excavation hole

3.2 Modeling small artifacts

During the work progress, small artifacts came up to the excavation surface. All of them were photographed, recorded in the original position, carefully removed by the archaeologists and kept in the archaeological site laboratory. Even no time restrictions have been setup for the mapping of the artifacts, usually this work was done in the afternoon. In the laboratory, a portable calibration field for control network establishment has been created (Figure 8). There, every small artifact was photographed in order to reconstruct the 3D model. Additionally, descriptive and useful information is recorded for further archaeological research and all data were stored in a digital archive library of findings.

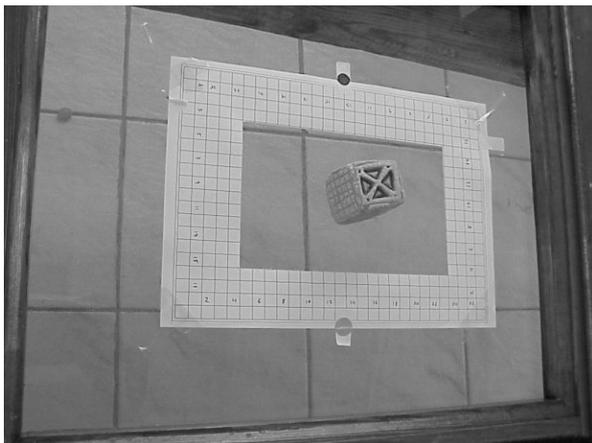


Figure 8. A small artifact

An example of a small artifact is shown in Figure 8. More than 15 photos have been acquired covering all the artifact's sides. A wide-use 3D modeling software (3D Builder) was used in order to reconstruct the artifact and produce the 3D photo-textured model. An example is shown in Figure 9. 3D Builder provide a solution of 0.45%. It should be noted that the accuracy estimate provided by the software refers to image scale and is very optimistic, i.e. 0.45% through the sensor frame of 4.8mm, multiplied by the image scale of 1:100 refers to 2.2mm on the ground (Patias et al., 1998). Additionally, due to the calibration field network, RMS values for check points calculated to 6.2mm, 6mm, 1.2 mm for X, Y and Z respectively.

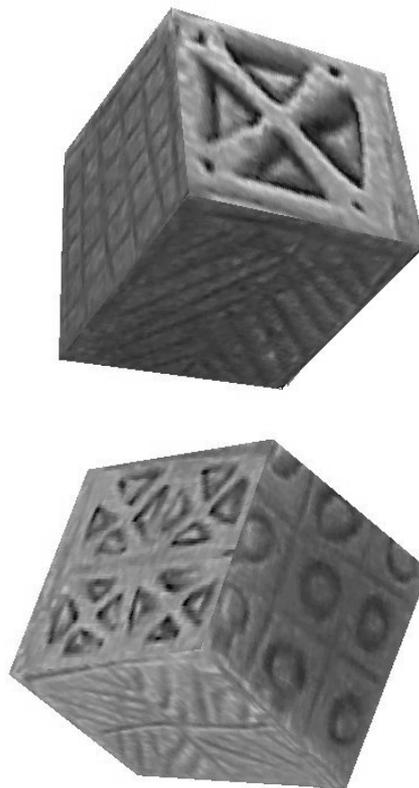


Figure 9. The produced 3D photo-textured model

4. DISCUSSION

The whole project has been organized in a way that the archaeologists would undertake the image acquisition. If photogrammetrists presence is not obligatory, all data will be transferred via internet for the photogrammetric processing. The produced orthophotos and then transferred back to the site for further archaeological work (e.g. interpretation).

The whole work can be more productive if the acquired images will be more close to an aerial case configuration. This can be achieved with useful structures (scaffold, telescopic arm etc).

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