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Photogrammetry for large scale documentation. The case of the microregion of the Minoan site of Gournia

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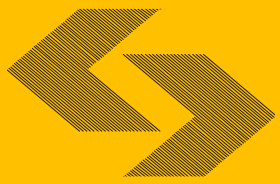

Photogrammetry for large scale documentation.

The case of the microregion of the Minoan site of Gournia.

R. Bieńkowski[1], M. Buell[2], J. McEnroe[3], and J. Botero[4]

Abstract-Today photogrammetry is a widely used tool in archaeological practice, although it is often auxiliary to traditional methods of documentation. In this paper we present a different perspective on photogrammetry, that is large scale landscape documentation of an archaeological site and its microregion. This method allows to gather large amount of data, that can be used to a wide variety of analysis focusing on the relation between the site and its environs.

1.INTRODUCTION

The present work is the result of an architectural and topographical survey carried out in the years 2010-2017. In this poster we would like to present the possibilities provided by large-scale photogrammetry for archaeological research.

The work presented here was conducted by the Gournia Excavation Project (2010-present) carried out by the University at Buffalo, SUNY. The site Gournia is located in east Crete (Greece), 10 km west from the village of Pacheia Ammos in the Lasithi prefecture. It was established in the Early Bronze Age (ca. 3,000 BC) and persisted through to the end of the Late Bronze Age (ca. 1,200 BC). The settlement's urban core was situated on a hilltop in a wide valley, while a cemetery and harbor installations were in its microregion.

The goal of the work conducted was to create a documentation, of the site, the landscape, and the region, that would be as precise as possible, while still respecting the limited time available for its execution. Such documentation is meant to give the opportunity to conduct, often complicated spatial analysis, at a later date including slope incline analysis, distribution of rainfall water, watershed, least cost analysis, viewshed, etc.

All the data is collected at one time. It can be subsequently transferred to various specialists greatly lessening the time they would need to spend on site, if not eliminating the need to collect additional spatial data altogether.

We consider the execution of such documentation of great importance in the light of significant ongoing changes to the landscape resulting mostly from the shift in the last 50 years or so from cereal agriculture and viticulture to olive tree cultivation. The latter is associated with frequent plowing and terracing, which has resulted in serious changes to the landscape. In addition, this documentation is timely, since there have been long-standing plans for the construction of a highway cutting through the northern end of the microregion.

Fig. 1. Aerial veiw of the site.

2. THE CONDUCTED WORK

The site documentation was divided into two broad components: 1) the construction of a detailed plan of the city, with special attention being paid to the architecture, using a Total Station to capture spatial data; and 2) photogrammetrical documentation of the site and its surrounding microregion. This paper is primarily concerned with the second component of our research program. Three kinds of photogrammetrical documentation was made in the course of work, they are shown in Table 1.

Before the data collection begun the following methodology was adopted. First of all we decided that the documentation has to be executed in two versions: a "light" version with low resolution and a "heavier" version with high resolution. Irrespectively of the resolution both types of documentation have to be executed in the highest accuracy possible.

All the aerial photos had a general georeference through the GPS module built into the drones. In the advanced version of the Phantom 3 drone the GPS location was aided by the GLONASS system. The geolocations taken with these components had a total error of 24 meters and were not sufficient for our purposes. The largest error occurred on the Z axis and was about 24 meters,

Photogrammetry restitution and attitude of photo sets collection				
Type documentation	terrestrial-based photogrammetry at a high resolution	medium resolution aerial photography	low resolution aerial photography	auxiliary documentation
Altitude	ground level	10-25 m above ground level	50-60 m above ground level	100 m altitude
Area documented	site	10-20 m site 20-25 m microregion	50 m site 50-60 m microregion	microregion

Tab. 1. Types of documentation exacuted for the site of Gournia.

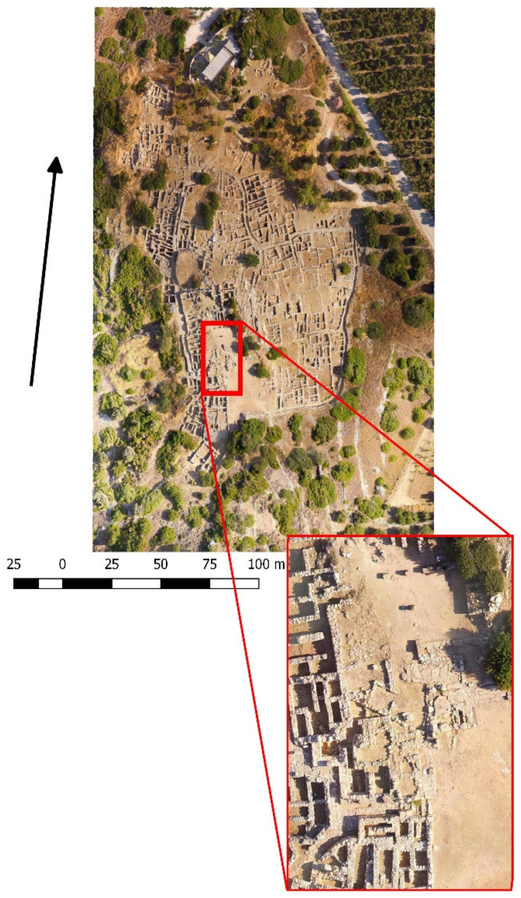

Fig. 2. Difference of resolution in the two, low and high, types of documentation in case of the town.

whereas the error on the X and Y axis was not larger than 3-4 meters. Despite the relative proportions between these measurements, this data could not be used for subsequent work.

For the purpose of increasing the accuracy of the georeferencing the whole investigated area was divided into sections. For every section, Total Station points of characteristic landscape elements were taken. For the area of the town additional sections were created, so that more points could be taken for that area. As the town is of exceptional interest to us, we wanted to increase the accuracy and obtain precise georeferencing.

The first step to create the final documentation, after the photos and measurements for georeference were taken, was to eliminate the photos that were out of focus and to calibrate the cameras used to take those photos. The remaining photos were analyzed and when parts of the drone were visible, they were masked, so as not to interfere on the later stages of the process.

In the next stage all photos were oriented on the common areas shared between the photos and on the general georeferences from the drone's components. Once the photos were oriented, a point cloud was generated. All subsequent work is based on this data. This point cloud was condensed from 800,000 points to 8.5 mln for the model of the whole region, and from 170,000 to 1,5 mln points for the town area. On average every square meter of the documented area was powered by at least 8 points.

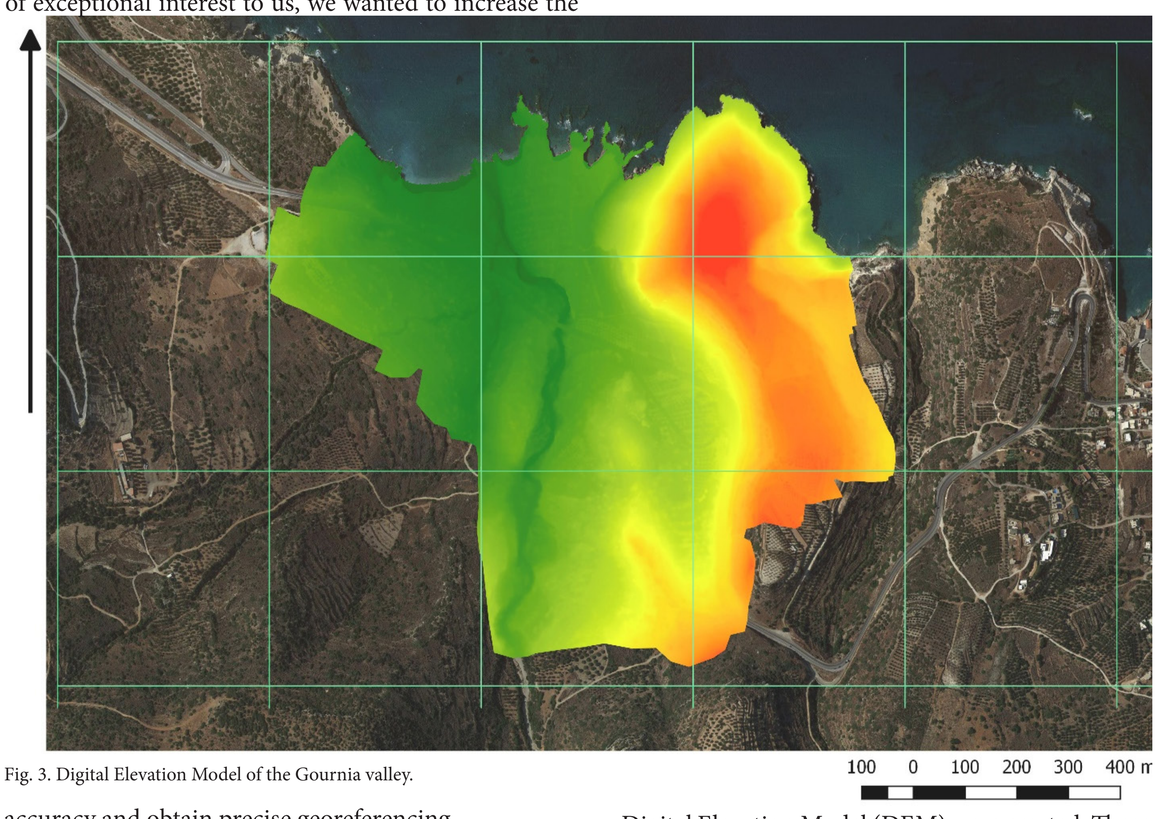

Fig. 3. Digital Elevation Model of the Gournia valley.

On the basis of the point cloud, the Triangular Irregular Network was created, describing the landform and was overlaid by photorealistic textures. Before the final documentation is generated, it is necessary to apply color corrections to the photos. Since the data was collected over a wide span of time, differences in the photos, resulting mainly from weather conditions, could not be avoided.

In the last step of the process the final documentation, in the form of an orthomosaic/photogrammetry and a Digital Elevation Model (DEM) were created. These will be used for the analysis of the investigated area. Those two types of documentation compliment each other providing a full range of information about the landscape.

Fig. 4. Final fotogrametrical documentation of the Gournia Valley.

The innovative character of the method lies not in the method itself, but **in the scale to which it was used,** since an area of over 1 sq. km was documented using the aforementioned method. In order to capture the three-dimensional data, two Phantom 3 (Advanced and Standard versions) drones were employed. The low altitude flights above the city were performed using the drone with the advanced configuration, while both were employed in the surrounding area. The final product of the work conducted is a series of orthoimages and DEMs. These are based on over 5,000 aerial photos, covering an area of over 1 sq km. The resolution of the final documentation of the town area is 1 sq cm for every pixel in the case of the high resolution version and 5 sq cm per pixel in the low resolution version. For the landscape documentation the resolution is 5 sq cm and 10 sq cm per pixel respectively. The accuracy of the final documentation is 25 cm for the town area and up to 1 m for the surrounding landscape.

The resolution of the DEM is 40 sq cm per pixel, and the accuracy is below 1 m.

3. CONCLUSIONS

The method employed at Gournia, presented above, is surely more time consuming than traditional large--scale aerial photography. It provides the investigators, however, with more control over the process and more detailed results. The use of drones, when compared to the planes or balloons, allows flights on lower altitudes with lower speed, which results in the better quality of the photos taken, as well as an easy repetition of the flight. At the same time, when compared to the more accurate method using ground surface data acquisition, whether photography or laser scanning, it limits the amount of entry data and it is much faster. The total time of flight necessary to cover an area as the one presented here does not exceed 8 hours. This method, however, is susceptible to weather conditions and the requirements of the drones themselves. In the case of Gournia it took about two months of field work and many hours of postprocessing of data to achieve our goals.

Through the use of the presented method we have achieved our primary goals: to document the city and its features, both built and unbuilt, and to situate these within their broader ecosystem. This documentation includes the construction of a detailed site plan, an up-to-date topographical map, a high resolution orthophotomap, as well as 3D models of Gournia and the landscape surrounding it. Not only will these results aid in further analyses of the site itself, but they will also provide us with information concerning the relationship between Gournia and its microregion. Finally, the models developed by this program will also be employed for purposes of site conservation and public interpretation.

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