FUSION of CULTURES

Abstracts of the XXXVIII Annual Conference on Computer Applications and Quantitative Methods in Archaeology,

CAA 2010

F. Javier Melero · Pedro Cano · Jorge Revelles

Editors

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Fco. Javier Melero, Pedro Cano & Jorge Revelles (Editors)

Granada, Spain

April 6-9, 2010

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Front cover and logo designed by Jorge Revelles. 3D Lion model courtesy of the Council of the Alhambra and Generalife. Background photo courtesy of José Manuel Rabasco.

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ISBN: 978-84-693-0772-4

Depósito legal: GR 1114-2010

IMPRESO EN ESPAÑA –PRINTED IN SPAIN

The Hill of Agios Georgios, Nicosia: 3D analysis of an on-going archaeological excavation

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1. Introduction

During the excavation the archaeologist requires detailed and accurate documentation of the whole excavated area and the different levels of the site (plans, sections, succession of layers, axonometries, volumetric information). This documentation is essential for accurate assessment and interpretation of the findings.

Technology is constantly developing, increasing the possibility to acquire more detailed data, particularly three-dimensional images of actions and artifacts and provides the opportunity to the archaeologist to obtain more accurate and complete documentation (BITELLI G., 2002, BITELLI G, et al., 2003).

Devices and software for 3D acquisition are become easier to use and more user friendly and technology can, therefore, afford and provide detailed results.

Three-dimensional models of objects, artifacts, and structures allow researchers to have a variety of views in studying them, and by applying some filters provided in the software, features that cannot be viewed with the naked eye become available.

2. Case Study: The excavation at the Hill of Agios Georgios (PA.SY.D.Y.), Nicosia

Apart from the remains of a circular stone structure which may be assigned to the Late Chalcolithic period, found on the south-west slope of the hill, where deeper deposits were preserved, the site is a large settlement of the Hellenistic period, built on a plan with parallel roads from East to West at equidistant spaces and a wide central road from North to South across the settlement. In between the roads there are buildings consisting of rectangular rooms of various dimensions with ample evidence for workshop activities. Terracotta, stone and metal objects were made on the site and weaving was also one of the major occupations of the inhabitants. Earlier remains dating to the Archaic and Classical periods were also found, even though the architectural remains from these periods have been seriously affected by the later rebuilding on the site. The cultic material from all the above periods is predominant and strongly points to the presence of one or more sanctuaries, for which most of the products of the workshops were intended. The settlement seems to have been abandoned some time after the middle of the 1st century B.C. and to have been reoccupied in the Late Roman period. On the north part of the site, remains of several kilns indicate a continuation of the industrial activities into the Christian period and a series of superimposed church buildings take the history of the site to the beginning of the Venetian period (Figure 1) (PILIDES 2003, PILIDES 2004, PILIDES AND DESTROOPER 2008, PILDES AND OLIVIER 2008).

Figure 1: *View of the archaeological site of the Hill of Agios Georgios..*

3. Methodology

The software used in this case study is Arc3D, a free software developed by the ESAT-PSI lab of K.U.Leuven (Belgium) and the Visual Computing Lab of CNR-ISTI (Italy), and JRC Reconstructor created by the EU-JRC (Joint Research Centre of European Commission). The integration of two techniques has been used for data acquisition: photogrammetry and laser scanning. For the first method a reflex camera was used, Nikon D90 (12,3 mpx) with 18-70 mm lens, and for the latter a phase shift laser scanner ZF Imager 5003 (produced by Zoller Frohlichwww.zf-laser.com).

The laser scanner was developed for applications on short and medium range (minimal distance between 40 cm and 53,5 m). It also guarantees an elevated acquisition resolution (max. 36.000×15.000 pixel: horizontal per vertical) with a speed of 500.000 pixel per second. Three profiles can be selected: Superhigh, High and Medium: at a distance of 10 meters the step of sampling of a High resolution is of 6 mm, while for the Superhigh it is double.

The data is acquired both in spatial coordinates x, y, z, and in the reflectance values. The latter, expressed in tones of gray, corresponds to the response of the materials to the beam. The system needs one or two operators on the field (D'ANDREA A., IANNONE G., SAFFIOTTI L., 2008).

The acquisition process followed the excavation of a small part of the archaeological site, with the aim to create a full documentation of the different layers and the realization of three-dimensional models.

3.1. Data acquisition process

The software Arc3D allows the automatic creation of a 3D model, from a photo set acquired with a digital camera that does not need to be calibrated (VERGAUWEN M., VAN GOOL L., 2006).

The outcome is a point cloud that needs to be scaled according to some ground control points.

Each trench of the site was positioned using a total station, measuring the position of the four corners which will be used as control points in the integration phase. The next step was the acquisition of about forty pictures for each layer of the excavated trench. In order to obtain a complete and detailed model from Arc 3D web server, the shooting has to follow some parameters: all the pictures have to be taken framing the same point and shooting every few steps, keeping the same distance from the focused object in order to guarantee a good overlap between the photos.

28 photos were taken, with a focal length of 18 mm, at a distance of about 3 m.

The same pipeline was followed for each trench of the excavated area in compatibility with the excavation activities to acquire the data of each excavated layer.

One of the disadvantages of this method of acquisition is that it is not easy to walk in an archaeological site because of the fragile emerging structures. In our case trenches of 4x4 m were used for the whole area and this allowed us to easily walk around the trench. Another limitation of the photogrammetry acquisition process is related with weather and light conditions. In particular for Arc 3D software the appearance of an object is very important because it has to be the same in order to obtain a detailed model. This is because the web server software finds matches between images for the entire process of the model creation. In this case, some of the set of pictures were acquired on two different days with different weather condition. Therefore some models present a different appearance.

After the data acquisition, the images were uploaded using the web service software and were automatically processed to create the 3D mesh of the captured scene.

Another step in the acquisition process was the integration of the models obtained with photogrammetry with the result of the data acquisition of the archaeological area with the Phase Shift Laser Scanner Z-F Frollich.

The laser pulse is deflected by a small rotating device (mirror, prism) and sent from there to the object.

For the data acquisition seven targets were positioned as ground control points, important during the post processing for merging the singular scans.

The acquisition campaign covered an area of about 650 m^2 and required about 2 hours.

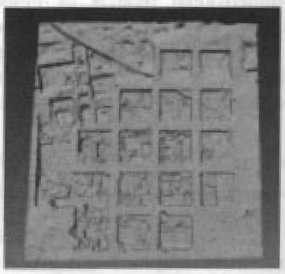

Figure 2: *Mesh of the excavated area view acquired from laser scanner (top view).*

The scanning was operated with medium resolution of acquisition (time required for each scan 100 sec).

The obtained point clouds were then referenced using the ground control points previously measured with the total station (Figure 2) (DONEUS M. & NEUBAUER W., 2005).

3.2. Post processing

The web service software Arc3D works with the open source software Meshlab (developed by the Visual Computing Lab at the ISTI-CNR). Sending a set of pictures to the server, after a while you receive a link for downloading the result.

This project-file has been processed in Meshlab for the elaboration of the 3D mesh processed by Arch3D server. The 3D model has been cleaned applying several filters (*Remove unreferenced vertex, Poisson reconstruction and vertex attribute transfer*). It has been applied the *Poisson Surface Reconstruction* for the reconstruction of continuous surface For the reconstruction of the model, obtaining a continue surface, was applied the algorithm Poisson reconstruction with octree 9. The texture was applied to the final model using the filter *vertex attribute transfer*.

The model has been scaled using ground control points, previously measured with the total station, that can be visible on the mesh. Finally the model was saved as ply file. The fifteen scans necessary to cover the excavated area, acquired with the laser scanner, were imported in the software JRC Reconstructor, as zfs files, using subsampling 1. Each scan was cleaned, removing the redundancy noise, and some filters were applied for filling holes and decimate the point clouds.

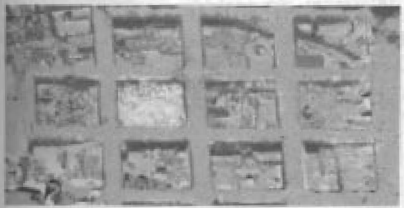

Figure 3: *Integration of laser scanner and photogrammetry model*

In the pre-registration process, all the scans were manually aligned using the targets positioned on the field. In particular each scan needs to contain at least three common points in order to allow the translation based on a rototraslation matrix.

Then the single scans were merged together and registered obtaining an average error of 7 mm.

The JRC Reconstructor has been used to integrate the 3D models of the trenches, generated with Arc3D, with the referenced point cloud of the area acquired with the laser scanner.

The point cloud was then referenced aligning the point clouds to some points of an existing plan in dwg file, drawn according to a survey of the area with a total station. In this way the point cloud was referenced to a local coordinate system (Figure 3).

Three ground control points have been recognized on 3D mesh from Arc3D and the models were rototranslated and aligned with the point cloud using a transformation matrix. The range error is 8 mm.

From these models, with the JRC Reconstructor software, it is possible to export orthophotos, draw plans and obtain sections and angular measurements.

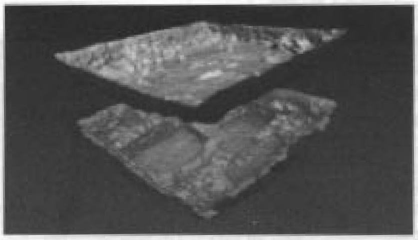

Figure 4: *Model of two layers of a square.*

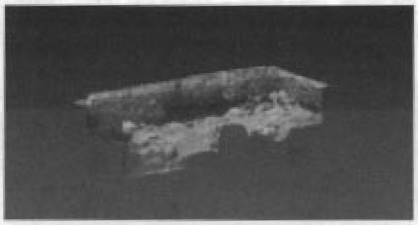

Figure 5:*Section of the model of the square with two overlapping layers.*

4. Conclusions

The three-dimensional visualization of the layers allows comparisons and measurements that are impossible to achieve using the traditional survey methods.

The two technologies have advantages and disadvantages, but their integration gives the opportunity of obtaining good results in terms of accuracy and time spent for the acquisition and elaboration.

One of the advantages of this method is that the layers are objectively represented and also that it is possible to integrate the 3D data with traditional surveys and drawings.

For the integration process the file ply was chosen, a file format compatible with the two software used: Meshlab and JRC Reconstructor . It contains vertices and polygon information, and the properties associated with each vertex, such as (x,y,z) coordinates, normal and color.

The two 3D models were optimized to decrease the number of triangles to facilitate and simplify the work, but there was some loss of the original information. This is a common problem because of the dense data generated by these technologies.

On the one hand the Arc3D survey allows to produce a 3D model within a short time and with a low cost., but the inability to use tools for geo-referencing inside Meshlab or Arc3d software increases the error in three-dimensional models of overlapping layers.

On the other hand the laser scanner acquires quickly and automatically a large body of data with an optimal accuracy, but the high cost of the instrument is prohibitive.

The result of the integration of the two technologies satisfied the expectations of the research, giving an integrated model with an error of 1 cm.

Therefore, following this pipeline, it will be possible for archaeologists to follow the excavation process from the beginning until the end of the excavation, obtaining a complete three-dimensional stratigraphy of the studied site and to locate the finds in their context.

Hopefully the low cost and user-friendly Arc3D tools will help inexperienced users to adopt these methodologies investing low efforts to obtain the desired results not yet completely used by the archaeologists.

5. Acknowledgments

This research is the result of a collaboration between : Cyl Science and Technology in Archaeology Research Center (STARC), Interdepartmental Archaeology Center (CISA), Department of Antiquities, Cyprus and benefited from the support of the EU-funded project 3DCOFORM (www.3d-coform.eu), (FP7/2007-2013) under grant agreement n° 231809.

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