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)

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Arc3D and 3D Laser-Scanning. A comparison of two alternate technologies for 3D data acquisition

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1. Introduction

The increase of 3D applications in the archaeological field raises some important issues. First, the accessibility, management and use of the reconstructions in order to evaluate, in scientific and critical terms the steps of implementation of the 3D models, and secondly the more accurate analysis of the various techniques and methodologies for 3D. Indeed it is not always used the best technology in relation to the objective of research, but one that is more available, with minor economic impact and management and ultimately more "simple." Particularly serious is the lack of reflection on the relationship between 3D technologies, methodologies and subject of study as if the use of techniques of image-based modeling, Laserscanning, photomodel was only related to subjective factors and totally casual. In another contribution we have highlighted the possible integration of techniques Laserscanning and Image-based modeling methods in the archaeological site of Pasydy, characterized by an excavation in extension.

In this article we will try instead to provide some ideas for a comparison between the techniques used. Comparisons that are presented are based on matrices have been developed to compare the two technologies and mathematical measurement of the accuracy and precision of the refund. Finally, from an analysis will indicate what we believe the strengths, weaknesses and critical in relation to the subject of study.

2. Study Case

In this study were used two different technologies such as photogrammetry and laser scanning, in parallel sessions, for the survey of the archaeological site of Pasydy, in the centre of Nicosia, Cyprus.

Pasydy is a rich and complex site, spanning almost the entire history of Nicosia from the Chalcolithic through the Medieval periods (Figura 1)

The surveyed area of archaeological site of Agios Georgios covers about 650 m^2, the whole area measure 49500 m^2. It is placed in a flat area and the excavation conditions helped the different steps of the survey: each excavated square measure 4×4 m and off one meter each-other.

In this study the results achieved with both techniques were then integrated to compare the outcomes and testing the accuracy.

Figure 1: *The archaeological area before the excavation campaign of 2009 (top view).*

3. Images registration and Arc3D

For the digital image acquisition was used a digital camera Nikon D90, with 18-105 mm lens, and the web service software Arc3D (free software developed by the ESAT-PSI lab of K.U.Leuven, Belgium and the Visual Computing Lab of CNR-ISTI ,Italy) (VERGAUWEN M., VAN GOOL L., 2006).

The recording of this area involve a big data capture. The survey begins with the acquisition and referencing of each trench. About thirty images was taken moving around the one square, maintaining the same distance and aiming always at the centre of the object.

The work covered one day for the acquisition of all the trench and each square was awarded in just over a minute, the time needed to frame the subject and get the pictures on many angulations.

There were some problems during the acquisition: first, the weather conditions, second provide for the takeover from a circular motion around the object in contexts like an archaeological site. The main difficult is due to the presence of multiple obstacles and different levels.

4. Post-processing

The acquired photos were uploaded with the web service software Arc3D and the results, downloaded from the URL received by email, were obtained in about one hour. The received file contains images, cameras, depth and count map. The time taken to receive the data changes depending on the amount of photos, the resolution and the correct acquisition of the photos. In some cases exceeded four hours.

Arc3D works inside the Meshlab software, a tool developed by CNR-ISTI Pisa, Italy. The model in Meshlab was optimized using the tools Poisson Reconstruction and Vertex Attribute Transfer.

The models thus obtained is not scaled. Therefore it needs to be scaled on Meshlab, using the ground control point measured with the total station.

The file format used to export the model was the ply, that associate with each vertex, such as (x,y,z), coordinates, normals and color.

5. Laser Scanner Technology and Methodology

For this case study was used a phase shift laser scanner ZF Imager 5003 (produced by Zoller Frohlich (www.zf-laser.com). The laser scanner was developed for applications on short and medium range (minimal distance between 40 cm and 53,5 m), with a speed of 500.000 pixel per second.

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 (D'ANDREA A., IANNONE G., SAFFIOTTI L., 2008). The 3D model obtained with laser scanning is an objective dataset which allows extracting information about the site morphology, geometric structure and materials. It gives a model that represents the real object.

The first step in the planning of the survey is to analyze the extension of the archaeological site in order to define the work to carry out.

Seventeen scan positions were necessary to cover the interested area, with the position of seven targets in order to help the alignment of the single scans. Each scan took 100 seconds for the acquisition with a medium resolution.

The work on the site required two hours for covering 650 m^2 following a well-consolidated pipeline (CAMPANA. S., FRANCOVICH R.; 2006) and campaign of photos was led in parallel using a digital camera (Nikon D90).

The software used for the acquisition of the range scans was ZF.

6. Post-processing

The single scans were processed using the software JRC Reconstructor created by the EU-JRC, joint Research Centre of European Commission (www.reconstructor.it.). It is a complete processing software for 3D data and for topographical measurements in combination with 2D digital images (SGRENZAROLI M.,VASSENA G.P.M. 2007).

The single scans were imported in the software as .zfs format with a subsample 1. Then were applied some filters for decimation, cleaning of redundancy noise for each scan. They were aligned with seven targets with a pre-registration tool in order to evaluate the error of overlap. Particularly each scan needs to contain at least three common points in order to allow the translation based on a rototraslation matrix The aligned scans were than fused in a unique model with an error of 7 mm (Figura 2).

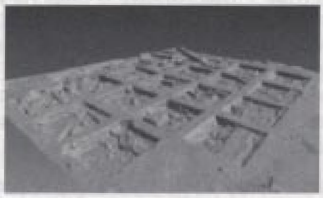

Figure 2: *Laser scanner model of the excavates area.*

The obtained model has been referred to a local coordinate system according to three points from a previous map elaborated with CAD software.

The final outcome can be used for many applications. It can be possible to extrapolate maps, sections, orthophotos, create videos.

7. Integration process

The models created were integrated, using the ground control points measured with a Total Station.

For each square was used three points scaling and integrating the two surveys. The JRC Reconstructor was used for the integration of the models realized with a rototraslation matrix. The photogrammetric models were thus overlapped to the laser scanner model (Figure 3).

Figure 3: *Integration of the two methodologies: Arc3D and laser scanning.*

The ply files format was used to import the 3D models in Meshlab and in order to verify the accuracy of the models and to compare both have been applied some filters (Filter/Color creation and Processing/Discrete curvatures) on Meshlab, and carried out on the 3D models some measurement that have shown in particular areas, like the boundaries, a maximum deviation between the two meshes of 2 cm, but in most of the areas perfectly overlap (Figure 4; Figure 5).

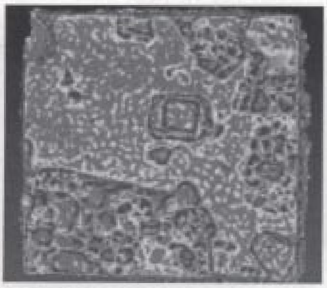

Figure 4: *Comparison between two meshes and measure of the deviation error: blu colour areas define the maximum deviation (2 cm), while green the minimum (top view).*

Figure 5: *Particular of mesh deviation.*

For each square	ARC3D	TLS*
Nr. of scans		2
Scans time		120 sec
Nr. of shots	28	
Shots time	120 sec	
Ground Control Points/Target	3/4	3
Elaboration time of WebService	2/4 hours	
Elaboration time of point cloud	300 sec	300 sec
Error of alignment		7 mm
Resolution	300 dpi	Medium
Distance from the object	3 m	5 m
Alignment time of two meshes	30 min	
Maximum alignment error between the two meshes	2 cm	

Figure 6: *Step and error of the different steps of the work for each square.*

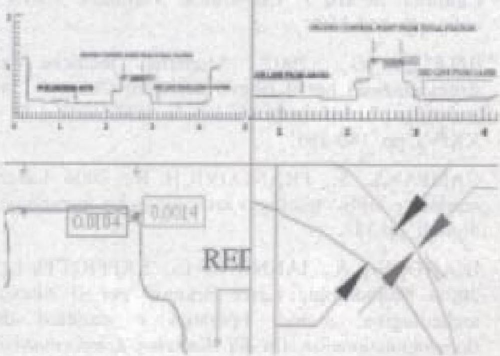

Figure 7: *Comparison between two sections from the two models near the Ground Control Points.*

8. Conclusions

The 3D data acquisition and modelling can be performed by different approaches. Advantages of Arc3D web service is his economic aspects, portability and a short data collection time. Disadvantages remain: the difficulty to follow the acquisition rules in archaeological environment, because of the different levels and obstacles you can find in an excavation; regarding the post processing the outcomes depend by the weather and camera model. This methodology is lend well to be used in determined archaeological contexts like as the object of this study or in the survey of details of the excavation and of the stratigraphy. But it must be placed side by side and integrated with other technologies, like in this case the laser scanner, for more complex contexts.

Advantages by using terrestrial laser scanners are the high accuracy of the 3D survey and the powerful 3D surface acquisition. In other hand, this technology produce a large amount of data that need to be reduced for further processing.

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