KOJTEPA 2013: THE USE OF 3D FOR THE DRAWINGS OF EXCAVATION: A METHODOLOGICAL APPROACH

Enzo Cocca (Università degli Studi di Napoli “L’Orientale”)

Introduction

In the frame of the new technologies applied to the archaeology, the 3D surveys are increasingly becoming a prime location. This occurs both in the development of tools to collect information and in the practice of compiling the documentation itself. The first is aimed at managing archaeological data and the second at keeping them detected as much intact as possible, avoiding to disperse any kind of geomorphological, structural and anthropogenic information. The 3D survey, thus, differs from the traditional methodology of achieving data, both for the completeness and the accuracy and speed of acquisition. In fact, applying this methodology it is possible to devote more time to the excavation, as in our case study, avoiding to halt too much for realizing drawings. Besides, the traditional survey should not be completely replaced. In fact it should not be forgotten that the survey is a functional operation related to the cognitive process, and then a key component in the archaeo-graphic processes (Medri 2003). Like any technical and technological innovation survey must always be examined both from the innovativeness, and especially from the archaeological point of view.

The use of 3D in archaeology is a recent methodological approach (D’Andrea et alii 2009; D’Andrea et alii 2011; D’Andrea and Barbarino 2012; De Felice 2012; Strong et alii 2006; Paripimeno 2006), which in the last years has seen an intense technological development both in the hardware and software. This has allowed one to think in a new way the activities of recording, analyzing and storing data. The three-dimensional model is a real database, allowing to extract morphological, and structural contexts of excavation, with a particularly high resolution. From the point clouds is, then, possible to extract plans, sections and lifted the archaeological site under consideration.

In the course of last campaign of the excavation on the site of Kojtepa (Uzbekistan) (Genito, Cocca, Raiano infra), next to the task of
managing the archives, it was possible to experiment solutions for the graphic documentation directly in digital 3D. The experimentation of born-digital documentation has led to test the use of SFM (Structure From Motion) during the work. This system is even more recent than the one used by laser scanner (Bigliardi *et alii*, 2013), and definitely it has a lower cost and less problems of use, especially in foreign countries.

The 3D survey is generally made using sophisticated tools such as laser scanners (e.g. Leica ScanStation2), which although present a high accuracy in the acquisition phase of the data collection, are, nonetheless, expensive instruments, delicate and cumbersome sometimes very difficult to transport. It is a tool that must be, furthermore, installed whenever there is need to do a survey. In our case-study one applies this methodology using three-dimensional survey alternative to the laser scanner with opensource software and a digital camera Canon EOS 1000D. In fact, using the algorithm SFM systems and image-based geometric elements can be extracted from simple sequential photos.

This alternative has allowed:

1. to avoid the paperwork for the import of equipment in Uzbekistan;
2. to quickly detect all the stratigraphic stages;
3. to continue the work of archaeological investigation without interruption;
4. to process data in the laboratory.

In addition to the 3D rendering, the plug-in PyArcInit (Mandolesi and Cocca 2013) of QGIS has been used in order to build stratigraphic units, to construct the matrix, alphanumeric, and digital data management.

PyArchInit is a plug-in for the opensource GIS software of QGIS, aimed at managing and analysing data relating to the cultural heritage in a single GIS platform using Python as the programming language and PostgreSQL / PostGIS (or SQLite / Spatialite) as database (Fig. 1).

In this work we show the goals, processes and results with respect to the time management, ranging from the data acquisition to the processing and graphic rendering.
Objectives

During the field work, the stratigraphic excavation of Trenches nos 5-9-10-11 were carried out by a fully opensource approach based on computer vision techniques for image based modeling, Structure From Motion, Clustering Views for Multi View Stereo (CMVS) and Patch Based Multi View Stereo (PMVS) (Lowe 2004; Furukawa and Ponce 2007; Furukawa 2010; Bigliardi et alii 2013). The main objective of this work was to produce high-resolution orthophotos (Figs. 2-6) of each stratigraphic unit to exploit the digitization in a GIS environment. The measurements have been, furthermore, used to draft a type of interactive .pdf documentation (Figs. 7-8) in such a way to make accessible the 3D visualization of the excavation without needing to install any rendering 3D specific program and only using the pdf Adobe Reader.

Following this procedure, the aim was to standardize the acquisition method, centralize the data in one system for collecting and managing in order to make available and leverage the same data in other applications such as WebGIS.

Phases of work

In this section we will describe the stages of work carried out, which applied the described methodology.

The work was divided into two main phases:

1. collecting data in the field;
2. processing data in the laboratory.

Regarding the first step, all the stages of excavation regarding the trenches examined, were documented by performing a series of sequential pictures on the stratigraphic units exposed.

The sequence of photos follows a specific order of a trend and recoveries fixed focal length (Fig. 9). In fact, every photo has a 70-80% overlap with the next and previous. This technique ensures that the work of processing the photos is recognizable in the overlay. Control points were also placed (minimum 4 and generally arranged at the corners of the area)
and detected with the aid of a total station and then recognized in the 3D survey (Fig. 10). These control points are necessary for geo-referencing both the 3D survey and the orthophotos.

The second step regards the stages of processing data which are divided into 6 additional phases of work:

1. 3D processing;
2. geo-referencing point clouds and mesh creation;
3. creating orthophotos;
4. warehousing excavation data in the database;
5. drawing the plans of excavation;
6. developing the documentation in PDF format.

The 3D processing was carried out, using Photogrammetry toolbox Gui (Moulon, Bezzi 2011). This is a connection written in Python providing a simple interface to execute Bundler + Dense point clouds computation via PMVS2 and CMVS (as WIP). The only parameter needed to use this software is the inclusion of the width of the CCD1 (Charge-Coupled Device) digital camera.

The development consists of 2 parts. In the first one extrapolates the features from the images and in the second one assembles these features and generates a “.ply” file format containing the 3D.

Each 3D series is composed of about 40-50 photos. All the excavation areas and levels were recorded using this methodology.

In addition, the reconstruction of the whole tepe has also been experienced using this same technique with poor results due to two problems: the natural light and the size of the area to record. In fact, the wideness of the area did not allow proper processing of the frames.

Trench no 5 has been recorded with seven 3D series, 439 digital frames in total, with a resolution of 10 megapixels each. The first three 3D series were taken only on the southern side of the trench, while the remaining 4 were taken over the whole trench for a complete reconstruction.

Trench no 9 was covered by a single 3D series, consisting of 135 digital frames with a resolution of 10 megapixels each. In fact, the SU exposed from the previous year, were covered only by SU 0.

1 The CCD is a sensor able to capture the image and transform it into an electric analogical signal.
In Trench no 10 two 3D series have been taken, consisting in 121 digital frames in total. These 3D series were intended to document a large jar and a floor with many pottery fragments.

In Trench no 11 four 3D series were taken, consisting of 225 digital frames in total. Being adjacent to Trench no 5, it was possible to correlate the various stages of excavation.

The 3D products have a dot density of approximately 500,000 points per object. Each 3D series has occupied about 3 hours of processing.

Once the object is created in the form of 3D point clouds, via software Cloud Compare and MeshLab, clean-up functions have been applied to noise, point clouds have been geo-referred through the control points, and mesh with the textures has created.

After the creation of the mesh, displayed according to the orthogonal planes, it was possible to extract the orthophotos.

The next step was to digitize all the information in the database about the excavation, both alphanumeric and geometrical through the compilation of PyArchInit cards. The DataBase using the shell for the management of the data is PostgreSQL 9.2. The orthophotos created with 3D were used as a base map for drawing in a GIS environment, from which they, then, created the excavation plans (Fig. 11).

Finally, the documentation of the excavation was produced in an interactive .pdf containing the 3D survey created with the information extracted from the DB. Pdf created is directly connected to DataBase using a connection ODBC\(^2\) (Open DataBase Connectivity).

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\(^2\) Open DataBase Connectivity (ODBC) is an API standard for connection to client at DBMS (rif. [http://support.microsoft.com/kb/110093](http://support.microsoft.com/kb/110093)).
3D processing is much more precise in the center than on the edges of the image. The problem seems to be due to the shooting mode: the central portion of the area appears in fact in a larger number of images, with respect to the marginal portions, which may also have been affected to a greater degree of optical distortion of the camera. This could be the origin of such homogeneities in the accuracy of point clouds and could be easily solved with a larger number of images or their better distribution along the object considered. The average values of divergence obtained, in conclusion, however, are consistent with the needs of the archaeological survey in the realization of traditional floor plans to scale excavation (1:20 or 1:50), but not in detail (1:10).

Conclusions

The work of archaeological survey, using the methodology above described, made in the 2013 at Kojtepa has permitted to carry out the excavation stages without interruption, thus, increasing uptime field research, since the acquisition of images was very fast and the time saved, considering that the data have not been processed after the excavation season. This allows a better planning of the research activities, above all when the time is limited. Moreover, the 3D data products are exploitable in an interoperable way in the documentation, through the creation of 3D PDF, and then easily discoverable.
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