

Computerised Techniques for Field Data Acquisition

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Abstract

The procedure presented and discussed in this paper was developed in order to reduce time and costs in the process of field data acquisition. By employing equipment which is commonly available and including image rectification software and a CAD programme, it is possible to carry out a photogrammetry analysis of any given structure found within an excavation, accelerating the time of acquisition and thus improving the productivity of the excavation work. Most of the measuring activity is thus transferred from the “field” to the “laboratory”, increasing the precision of the drawings and preventing problems derived from difficult field conditions.

The data collected according to this system can improve both the scientific analysis of the information as well as the diffusion of results, since they can be processed into:

- *an archaeological hypertext, which offers access and the possibility to analyse all the information produced by the investigation*
- *a 3D model of the archaeological stratigraphy, which virtually reproduces the original situation and its “dismounting”.*

Key words: photogrammetry, image rectification, 3D model, light archaeology, database, building-technique typology, stone-finishing typology

This paper aims to address the problem of significantly reducing the time required in the field for acquiring drawing data. This method is suitable for acquiring spatial data as well as measurements for structures which are almost vertical, and it was also tested on horizontal surfaces.

1. “Light” archaeology

During the last few years, the research team for Medieval Archaeology, directed by Professor Guido Vannini (University of Florence), has adopted a system of territorial analysis, which has been labelled “light archaeology”. It is a system based on the integrated use of non-invasive methods which characterise Landscape Archaeology, Environmental Archaeology and the Archaeology of Upstanding Fabrics, and is made possible by information technology. This methodology aims to produce a series of interconnected data (for example, creating dedicated atlases) concerning material sources which were stratigraphically recorded. This approach can also include stratigraphical excavation, especially for clarifying specific aspects which emerged in the course of the research.

Information technology plays an important role in setting up specific research tools that could guarantee standardisation on one side (for example, a specific recording sheet was developed) and flexibility on the other side, in the sense that they can be adapted to different contexts (a site, a topographic unit) and logistic situations (time, resources, competencies available).

2. Field research

Field research carried out by the team of the University of Florence, department for Medieval Archaeology is based on strongly connected procedures of archaeological investigation. As mentioned above, the methodology is based on the Light Archaeology approach and on stratigraphical excavation. Information technology integrates and links all collected data into an articulated system. A photogrammetrical system for recording data in the field has recently been implemented in our group in order to acquire detailed prospects, sections as well as architectural and excavation details.

By employing image rectification software¹ and a digital camera it was possible to experiment in the general use of photogrammetry in a variety of cases, especially where normal acquisition procedures have proven to be difficult, too slow or too costly. Preliminary results which clearly need further processing were recorded using this simple equipment² and the results are comparable to those achieved with more traditional methods. Substantial time reduction for acquiring data from excavation layers or upright structures can be noted: this approach allows the optimisation of archaeological field operations and offers great improvement in the computer drawing precision. Furthermore, the advantage of this method is that it can easily be taught to those who generally operate on excavations: after a short introduction to this method and its procedures of numerical data registration, image digitising

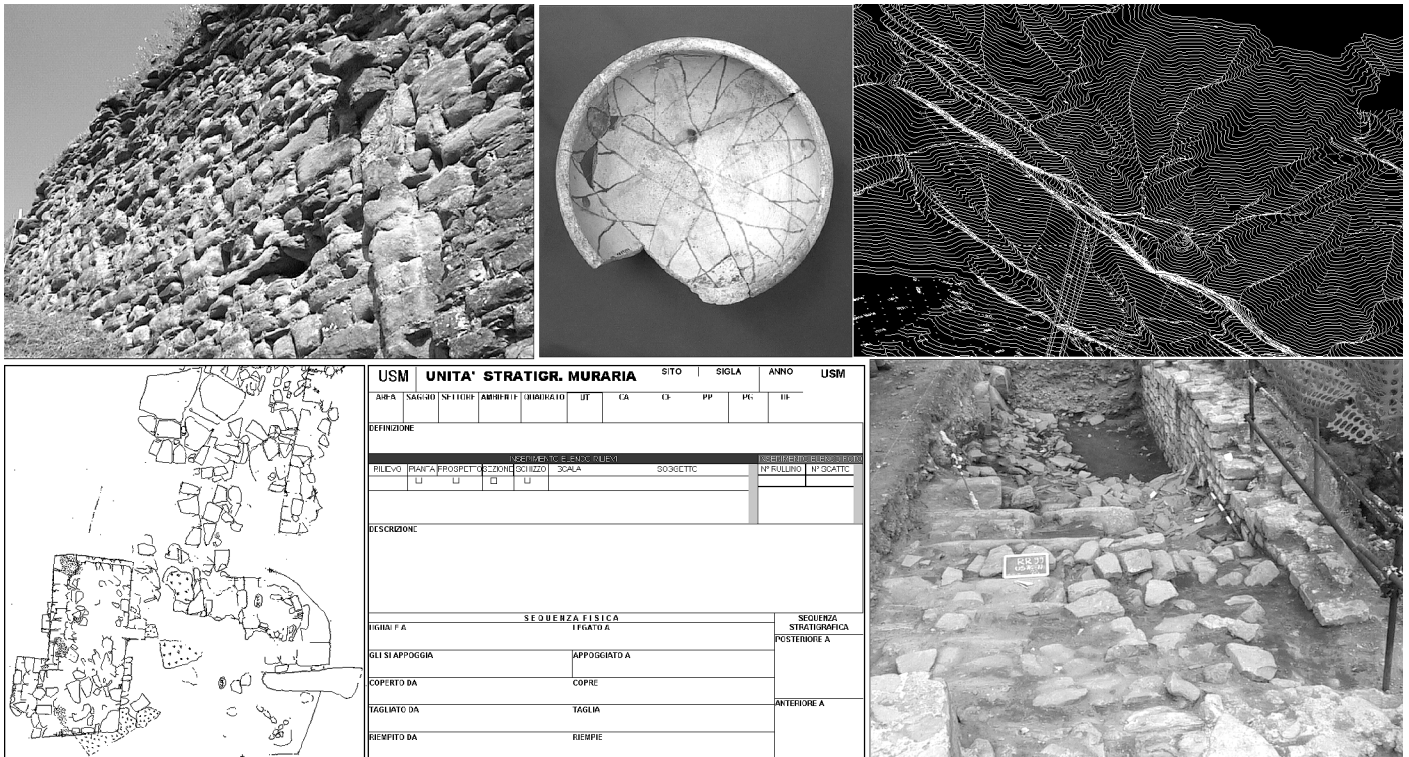


Figure 1: An example of data recorded with the Petradata database.

and rectification, it could be performed by a number of students of Medieval Archaeology.³

Furthermore, photogrammetry proved to be fundamental for the acquisition of archaeological graphical data, especially when it would be difficult to operate with traditional methods without high-cost equipment; this is the case, for instance, at physically inaccessible structures as can often be found in Jordan, or unsuitable weather conditions, as found at Rocca Ricciarda, Italy.

However, the method has some limitations; for instance, remarkable difficulties can be encountered in its application to circular structures or to archaeological layers spread on different levels, when it is not possible to provide an accurate graphic restitution without some special device for taking photos perpendicular to the ground.

3. Rocca Ricciarda castle

Because of its limited size, Rocca Ricciarda castle was regarded as an ideal archaeological site for experimenting with the new method of data acquisition.

Rocca Ricciarda is a small medieval castle located near the Arno Valley, Tuscany, in central Italy. The castle has been abandoned since the end of the Early Middle Ages. Written sources are found in abundance and have proven to be very informative, and their study allowed to partially reconstruct the history and the dynamics of the medieval settlement and its historical context in the Arno valley. Research carried out in the archives provided interesting results both in terms of quantity and quality; for example, the sources provide the names of the soldiers in charge of guarding the castle's tower in the years 1260-1285.

In 1997, a team from the University of Florence carried out a campaign of archaeological investigation with the aim to analyse the up-right fabrics of the medieval fort at Rocca Ricciarda. The

1999 campaign was aimed at the total excavation of the settlement in order to obtain a complete stratigraphic record. A restoration project will be launched at the completion of the archaeological investigations.

In this research, we attempted an experimental approach in order to obtain a totally computerised archaeological record, involving data acquisition and document archiving, as well as processing and dissemination of the results, both at a scientific level and on a laymen's level as far as communication and popularisation are concerned.

In an attempt to address various problems which emerge during the course of research, survey and storing archaeological records at the excavation site, computer experiments have paralleled the archaeological investigation. The database management system called *Petradata*⁴ integrates all different recording sheets used in the field into a single standardised database. Its main features allow the user to create a database for archive management, as well as consultation and record cataloguing (figure 1). Apart from this it also enables the user to acquire digital images of the excavation, the survey and of the finds, to draw digital maps, prospects, sections, and so on.

The experimental method differs from the traditional method in the intensive use of the computer and it can be described in four phases. The aim of the described operations is that of obtaining a three-dimensional model of a given archaeological layer.

The first phase follows the traditional approach and consists of tracing notable points; usually these are external vertexes of the excavation area and they are established with traditional optic beads and with a theodolite.

In its second phase, the experimental approach differs from the traditional one. The example of application discussed here deals with a stratigraphic unit which consists of a wall of the collapsed tower of the Rocca Ricciarda castle, and which can be best de-



Figure 2: Rocca Ricciarda castle. The rectified photograph of the ruins.

scribed as a deposit formed by a significant number of stones. With the traditional method, all the vertexes of every individual stone should be taken one by one, measuring from the notable points, and at the same time drawing the outline of it on a sheet of paper, which results in a high investment of human resources and a possible loss of accuracy.

With the method tested here, a rectangular grid is set across the area to be recorded, thus providing a horizontal “0 level” for further measurements. The X and Y co-ordinates of the vertexes of this grid are then established: the photographic reading which will be later on computer processed is based on these points. The method proceeds to the graphic restitution of these points with a digital photographic camera; photographs must include at least six vertexes, and they should be as parallel to the ground as possible.

In the third phase, one person downloads the digital photographs and carries out their rectification on the computer by means of specific software; two others carry on with the work in the field. The Z co-ordinate for a number of points on the various stones of the collapsed tower is obtained by measuring from the zero-level created by the grid; these co-ordinates are recorded directly on the rectified photographs of the “zero-level” grid.

In the fourth phase, all data is processed onto the computer: rectified photographs are transformed into vectors by the means of a CAD programme and they are eventually imported into a 3D program for three-dimensional representation.

As mentioned above, the case considered here refers to the collapsed wall of a tower of the Rocca Ricciarda castle. The figures presented here illustrate the process of acquisition, analysis and storage of 3D data. The first is a rectified photograph (figure 2) and the second is a detail of the same photograph processed into the CAD system (figure 3). The result is a digitised image of the stones found in the ruins and a 3D shaded model of the same stones. This is obviously a static screenshot but with the CAD system we can rotate and observe the ruins from different points of view.

This system will be of great importance at the reconstruction of the process of archaeological excavation (both for scientific research and for teaching purposes) and at the same time it will put into context the archaeological layers.

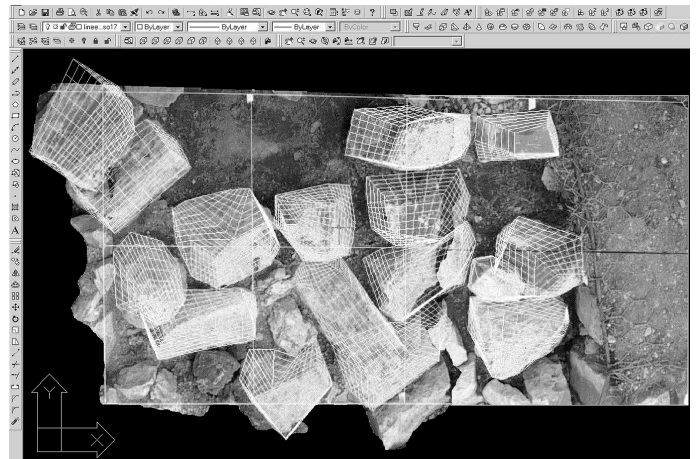


Figure 3: Rocca Ricciarda castle. Detail of figure 2 processed into the CAD system.

The final goal of our research is that of creating a 3D model for the entire site of Rocca Ricciarda and place it in the context of its landscape.

4. Shawbak castle

To further illustrate the methods employed by the team, the case of the Shawbak castle (Jordan) will briefly be discussed. Since 1986, an Italian team from the University of Florence (directed by Prof. Guido Vannini, for further details on the research team see the acknowledgements), is carrying out an archaeological research project in Jordan; the research is aimed at analysing the characteristics of a Crusader settlement in the area, and is focused on the Petra system of fortification; the castles of the Petra valley and the castle of al-Shawbak played a fundamental role in the control of the trans-Jordanian territories; moreover, the original features of the Crusader presence in the Holy land are particularly well preserved in the Petra valley because most sites were abandoned after the Crusaders were defeated by Salah ad-Din in the battle of Hattin in 1187.

At present, archaeological data concerning the site of Shawbak is rather limited. In particular, there is, as yet, no detailed map of the site. The earliest map available in literature is a draft drawn by the scholar Mauss in 1871; it shows the perimeter of the fortress, including most of the towers. A more detailed map has been drawn on the basis of an aerial photo survey, sponsored by the Spanish Archaeological Mission in 1978 (Almagro 1980:119). For our preliminary survey of the site we took advantage of the latter map.

In the first stage, the aim of the research at the Shawbak castle was to identify the related building phases and to record the various building techniques in order to gain an understanding of the evolution of the fortified settlements in Trans-Jordan. In a very limited amount of time (approx. 10 days), and with the use of simple equipment, the team carried out the stratigraphical analysis of selected castle structures. A preliminary stratigraphic sequence for a number of structures was established, and this formed the basis for the first attempts to interpret the castle phases; a preliminary atlas illustrating the various stones cutting and finishing was also produced. A number of research topics to be developed in the course of further research have also emerged.

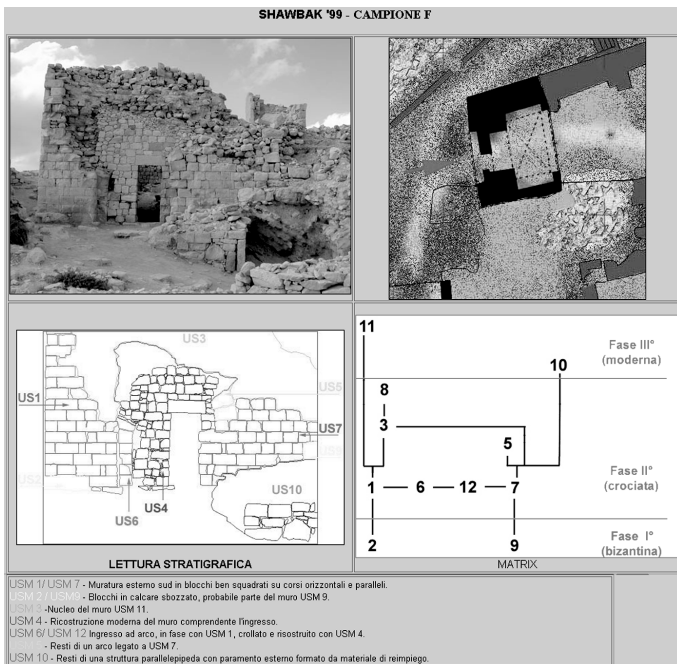


Figure 4: Shawbak castle. The stratigraphic analysis of the inner gate.

After the completion of work, the results will be published on the Internet in a section of the site dedicated to the *Medieval Petra*⁵ project.

To illustrate the achieved results, the 1978 map was adopted; on this map, a preliminary interpretation in terms of major building phases is represented by the use of different colours. A series of arrows on this map indicate the points of the photogrammetry shots; the arrows are linked to pages that illustrate the stratigraphical analysis of the structure itself. For example the page related to the inner gate (figure 4), shows a rectified photo, a map, the stratigraphical analysis of the structure and the related matrix (with phases). A detailed analysis of each stratigraphical unit can be seen by clicking on the drawing, and one can also observe the rectified photo, the digitised drawing and the stone surface, classified according to the preliminary typology.

The building-technique typology (figure 5) had been conceived as an Internet page consisting of a short description (including measurements) of the wall structures, rectified photos and the digitised drawings. We are also in the process of preparing a database for this data, which will enable direct access.

The typology of the stone finishing has been conceived as a similar page with a general photo, a detail, and a short description with measurements. A database which will allow direct access and comparison is currently in preparation.

5. Conclusions

The results of the experimental procedure described here have underlined that the developed methodology is applicable to different situations, showing both great flexibility and adaptability.

The experimentation carried out at the castle of Rocca Ricciarda underlined its reduced cost; in the course of the next archaeological campaign we also plan to speed up this process with the support of DGPS equipment.

SHAWBAK '99 TIPOLOGIE COSTRUTTIVE CROCIATE

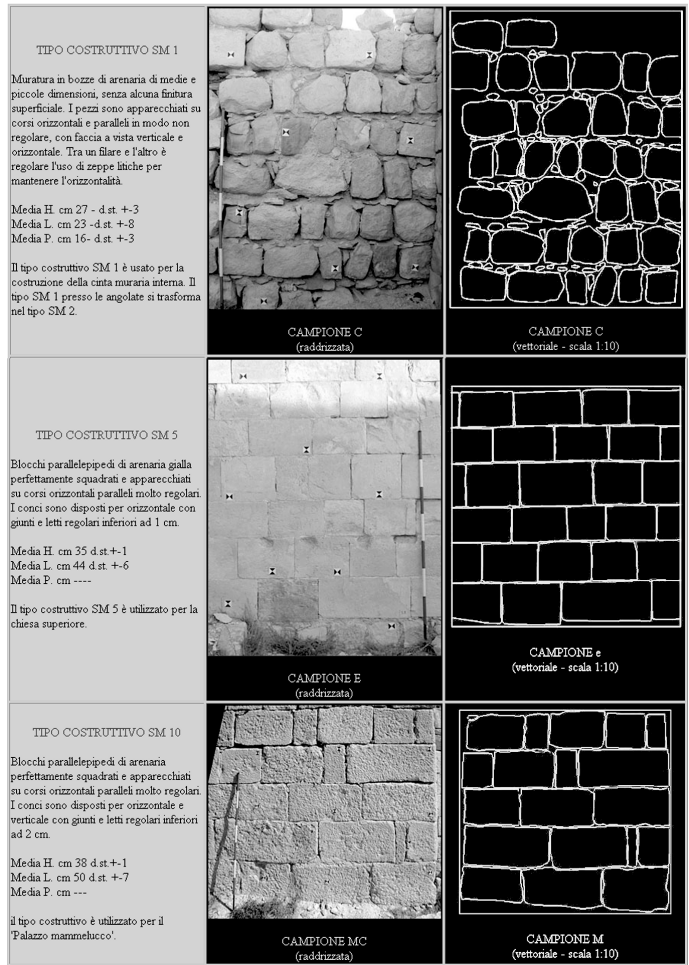


Figure 5: Shawbak castle. An example of the building-technique typology.

The application of this technique to the case of Shawbak showed its speed in the phase of data collection and processing; moreover, the results gained through this method are promptly made available and can be used in the continuation of the field research.

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Some maps and sections of the castle of Shawbak are taken from the unpublished thesis of Andrea Iacono and Stefano Mariucci.

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Armenian Architecture - Virtual Ani: [http://www.virtualani.freeseerve.co.uk/Armenian Architecture - Virtual Ani - Map Of The City.htm](http://www.virtualani.freeseerve.co.uk/Armenian%20Architecture%20-%20Virtual%20Ani%20-%20Map%20Of%20The%20City.htm)

Fields of Application for Photogrammetry and Imaging in Archaeology: <http://www.univie.ac.at/Luftbildarchiv/wgv/appl.htm>

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Il raddrizzamento fotogrammetrico. seminario di Marco Canciani a.a. 1999-2000: <http://www.uniroma3.it/sta/DIS/ricerca/ortho/teoria.htm>.

Notes

- ¹ The software for image rectification is Siscam-Archis 32. It allows to turn a central projection frame of a raster image into a orthogonal projection that can easily be transformed into vectors and measured. Two different methods are used for rectifying: geometric omografias and analytical omografias. These two methods allow the performance of image rectification (both knowing the co-ordinates of certain points of the photographed object or lacking any known points).
- ² The equipment used consisted of: 2 Personal computers Pentium 266 with 128 Mb Ram; 1 digital camera Nikon Colpix 950; 1 scanner Primax Colorado Direct; Microsoft Access for text data storage; Microsoft Excel for numerical data processing; Adobe Photoshop for image processing; Siscam Archis 32 for image rectification and mosaicing; for final processing the following programmes were used: Autodesk Autocad for vector graphic restitution; Rhinoceros and 3D studio Max for 3 dimensional modelling.
- ³ The method consists of the acquisition of images with a traditional or digital photographic camera; acquisition of the co-ordinates of an extremely limited number of points on the object; and of image processing by means of PC software.
- ⁴ Petradata is an open, flexible and dynamic system of interconnections between recording and storing archaeological data. It integrates the various types of recording sheets used in the field into one standardised database. Data entry is performed using input forms that reproduce the structure of the recording sheets used in the field.
- ⁵ The site can be accessed through the server at the Dipartimento di Studi Storici e Geografici, University of Florence, at address: http://www.storia.unifi.it/_PIM/AM/Petra/italian/medievalpetra.htm