EVOLUTION OF SURVEYING PRACTICES IN ARCHAEOLOGY: A TECHNICAL OVERVIEW TO INTRODUCE NEW MANAGEMENT POSSIBILITIES FOR CULTURAL HERITAGE DATA

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ABSTRACT

Especially in archaeology, a mission of the surveyor is to acquire and to work on data generated by an experimentation field, i.e. to locate natural elements or human constructions, and to represent them (analogically or digitally). Surveying work has always been part of field archaeology, because the knowledge and expertise of the surveyor can be as useful for the prospecting stage as for the excavation. However surveying practices carried out in archaeology could change, and the surveyor could be proved helpful for the use of excavated data too. The purpose of this paper is to summarize how topographical techniques are used by the archaeologists, and to present the evolution and potential of computer developments, especially regarding data management. Historically, a number of cartographic tasks in archaeology was taking care of by the surveyor, e.g. cartography of excavation fields, absolute positioning of distinct sites, aerial prospecting, study of old maps and archive images, levelling, etc. Today, the archaeologist makes more and more the field surveys himself, however the role of the surveyor could change in the future. He will be able to help the archaeologist in his data exploitation work as well. The new expertises of the surveyor, e.g. Databases and Geographic Information System (GIS), allow him to handle different kinds of data efficiently. These knowledge should be interesting for the archaeologist, both in simplifying data management and in developing novel techniques for presenting the resources. Moreover, to have an overview of all data available could lead to innovative analyses, based for instance on interactive 3D models linked with databases or on modelling of historical evolutions. Then, the surveyor competences are extending and will permit him to offer the archaeologist new possibilities for the utilisation of all types of documents allowing to approach the Human Past.

1. INTRODUCTION

This paper gives a technical overview of surveying practices in archaeology, to show their evolution and the perspectives that appear thanks to computer developments, particularly regarding cultural heritage data management. This study comes within the context of research conducted as part of a Ph.D. thesis entitled "3D acquisition, restitution and imagery in Archaeology: towards a platform linking computer graphics and cultural heritage data". This project is managed in the Photogrammetry and Geomatics Group MAP-PAGE, National Institute of Applied Sciences (INSA) of Strasbourg, in collaboration with the Research Centre in Architecture and Engineering MAP-CRAI, Nancy School of Architecture. Since several years, digital tools and applications dedicated to architecture and cultural heritage have been developed in these laboratories.

Then, this study proposes an outline of the use of surveying techniques in the archaeological problematic, to introduce new possibilities for the management of data accumulated in archaeological sites. Actually, the working of a site generates a large quantity of cultural heritage resources, and computerized tools are required for the treatment of the various data as a whole. The surveyor with his new expertises, e.g. notably Databases and Geographic Information System (GIS), is therefore able to find solutions to help the archaeologist in his tasks. His job is changing, moreover knowing that today the archaeologist makes more and more the field surveys himself.

The article can be broken down into two parts: the common practice of surveying in archaeology and its evolution, and then the potential of the computer for the management of cultural heritage data. The first part of this paper deals with surveying work on an archaeological site. Two steps are coming out: generalities on the link between archaeology and surveying, and examples of common surveying practices in archaeology with their current evolutions. The second part concerns the new expertises of the surveyor and the potentialities that follow for data management. Three aspects can be considered: the reasons for computerizing archaeology, the knowledge of surveyors for the data management, and finally the benefits of data computerization for the archaeologists.

2. THE COMMON PRACTICE OF SURVEYING IN ARCHAEOLOGY AND ITS EVOLUTION

The main speciality of the surveyor is the terrestrial or aerial localization of natural elements or of human constructions, and their analogical or numerical representation. He can therefore, by his technology, help the archaeologist for its field work.

2.1 Generalities on the link between archaeology and surveying.

Archaeology is a discipline of history, which is distinguishable by the specificity of its objectives and research methodologies. It concentrates particularly on the study of our ancestors way of life and of their manner of thinking. Then, the archaeologist collects and analyses a lot of documents, of whatever character (cf. third part), allowing him to approach the human past.

From a practical viewpoint, a distinction between field archaeology and office archaeology can be made. Field archaeology is the part where the expert carries out excavations, gathers traces and collects evidences. Whereas office archaeology get together researchers who study in laboratory these evidences of the past, to draw conclusions permitting to reconstitute the men's life at a given epoch. It is then worth nothing that to be able to draw valid deductions of this studies, it is important not to isolate the found objects from their

context. Consequently, the problem of planimetric or altimetric location of evidences within an excavation field is primordial for the archaeologists. This has always been one of the major job of the surveyor on archaeological sites.
Moreover, the archaeologist has considered for a long time each excavation field as an isolated and independent site. He has made no necessary arrangements to be able to link up diverse geographically nearby sites, especially if the excavations were carried out at different epochs. He is now aware of the backgrounds of such methods and, very often, a surveyor is part of the field team to solve this problem. The surveyor can thus connect each place with a wide area coordinate system or with some fixed points, natural or artificial, so as to be able to link up the different sites.
So archaeology clearly serves history, but it is also served by numerous disciplines like historical sciences (palaeography, epigraphy, toponymy, chronology, etc.), technical sciences (photography, seismology, geology, physics and chemistry, surveying, cartography, photogrammetry, etc.), and artistically sciences and techniques (architecture, painting, ceramic, etc.). Surveying practices are of course part of these subjects, because they provide archaeological operations in their different phases, which are described in Table 1.

prospecting	study and search of a site, which has a great likelihood to contain relics of the past, and which will be excavated in case of positive results
excavation	field work required to bring out the relics, and to locate and survey the different evidences
inquiry	laboratory studies and research that lead to the publication of the results and of the work's conclusions

Table 1. Different phases of archaeological operations.

In the next part, some details and examples of the surveying practices carried out in these different phases will be given.

2.2 Examples of surveying practices in archaeology and their current evolutions.

The surveyor with his training, polyvalent but particular in the scopes of topographical location, cartography and land problems, can clearly put his competences in the archaeologist's service and can be very useful for him. As we will see next, this is particularly true in the two first phases of any archaeological work (prospecting and excavation), but also in the inquiry phase, as it will be explained in the third part of this paper.

2.2.1 Archaeological prospecting: Before he begins an excavation work, the archaeologist must perform complex research and has to discover a favourable site, having goodchances to contain relics of the past. The process is methodicaland is made up of three phases:

1) the preparation;
2) the aerial prospecting;
3) the search on the field.

The surveyor can get involved in each of these phases.

1) The preparation consists of the study of all available documents and of the gathering of numerous information. One of the problems of the search of an archaeological site is the fact that relics are often buried. The archaeologist must then dig the earth to found the objects, and to avoid errors, he has to search indications that testify of the human presence. For instance, some signs of the location of a prehistorically archaeological site can be given by the toponymy of places. The localities names, written on the cartographic documents made by the surveyors, are thus very significant, and it is very useful for the archaeologist to refer to maps and ancient plans, to charters and deeds executed by a notary, so as to archives of the local historians. Moreover, it makes sense to perform comparative studies of ancient maps, on the one hand, and recent cadastre, on the other hand. These studies often reveal changes, disappearances, modifications, emergences, both in the layout of places and in the existence of buildings or sites. Old maps have not systematically a great topographical value, but they are precious because they can show the location of lost monuments. In these scopes, the surveyor can therefore give useful information to the archaeologist, thanks to his knowledge in both ancient and recent surveying and cartographical techniques. This preparation phase evolves with the development of computerized techniques in surveying, which make easier especially the comparison between several documents (cf. part 3.).
2) The aerial prospecting afterwards can confirm a hypothetic site location, found during the preparation phase. In fact, before to start an expensive excavation operation, it should be advantageous to be sure that the site contains evidences of the past, and aerial photographs of this site can show some traces of the buried monuments. Since a hundred of years, archaeologists have begun to use altitude photographs from balloons, kites, and later planes, to capture groups of antique monuments. They have had very early the idea to employ the photogrammetry created notably by Laussedat towards 1855. Thanks to a ground cover proportional to the plane's height, aerial photographs allow to eliminate the useless details on the shot, to let appear only interesting groups. It is also possible to obtain views of relatively large regions. The main advantages of aerial photographs are: -the possibility to define zones of interest; -the positioning of archaeological relics in their context; -the opportunity to draw regular plans of the selected zones; -the archiving of the observations; -the examination at leisure of the field images. According to (Doneus, 1996a), the principle of aerial archaeology is based on the use of distant view. Archaeological sites show up on the ground surface, depending on their state of preservation, by light-shadow-contrasts, tonal differences in the soil or differences in height and colour of the cultivated cereal. In that way, settlements, graveyards, fortifications, etc., produce specific structures, that can be identified easier from a high viewpoint (the structures are clearer and the pattern are more understandable than while standing on the archaeological feature).In practice, oblique and vertical photographs are taken (Figure 1). The first allow, by a monoscopic cover, to capture whole the vestiges, above all for the illustration of the final publications of the work. The second, on another side, are necessary for stereoscopic observation and eventually for restitution with the aim of drawing regular plans. This restitution based on the aerial photographs, but even an easy photographical rectification, require a stereo-preparation, which consists of the designation of a set of homologous points between the field and the aerial photographs. The surveyor has a key role in this moment to determine, by terrestrial operations, the planimetric and altimetric locations of these control points.

Figure 1. An vertical photo showing Delos vestiges (with a squaring for future adjustments).

More generally, as a specialist in photogrammetry, the surveyor contributes to apply imaging techniques to archaeology (Table 2).

analysis of vertical and oblique photographs	archaeologists want to have exact and detailed mappings of the archaeological information of the photos
visualization of the site topography	contour lines, digital terrain models or profiles of the surface can be depicted together with archaeological information from photos or from results of excavations
production of digital orthophotos	very important aid for archaeology structures showing up on the surface are depicted together with all of the image-information image enhancement, pattern recognition and subsequently expert systems are applicable with orthophotos
Geographic Information System (GIS)	combination of the data mentioned above with results from other (especially geophysical) prospecting techniques (cf. part 3)
"Predictive Modelling"	to assess the likelihood of finding significant archaeological materials in given areas, thanks to data acquired by satellites

Table 2. Imaging techniques for archaeology (Doneus, 1996b)

Imaging techniques evolving very fast nowadays, there are more and more potential applications in archaeology, and more and more possibilities for the surveyor to help the archaeologist by new means.

3) The search on the field finally is the prospecting phase that permit to validate the two previous. The identification of a site is made by a critical observation of the field, so as to detect the attendance of evidences thanks to reliable marks. These signs could be irregularities of the ground, anomalies of the vegetation, layouts of old thoroughfare, strange arrangements of rocks, etc. Checking the conclusions of the previous studies can be carried out by different means, for instance:
   - creation of Digital Terrain Models, made by field or photogrammetric surveys, in order to calculate and to model the irregularities of the ground, for a computerized analysis before the excavation;
   - electromagnetic measurements for the search of metallic elements;
   - ground resistivity measurements, depending on the chemical composition of the soil, on its structure and water content: walls and old ditches will react another way than the soil around, and will thus be highlighted;
   - magnetic measurements, from which the small local variations can be due to heterogeneities of the ground;
   - seismic exploration.

   These methods have the advantage of being non destructive and they can therefore be used without damage to every type of ground. The observations done allow often to determine accurately the place propitious to the excavations, but the strict proof of the archaeological site nature can only be given by fruitful borings. Positions of these borings will be determined precisely thanks to the plans made by the surveyor during the aerial prospecting.

2.2.2 Excavation and survey: The first task to be realised on an excavation field is the establishment of an exhaustive plan of the site. Based on the wider map carried out during the prospecting phase, this plan can be prepared jointly by the surveyor and the archaeologist. The aims of this surveying document are the followings: -to acquire an exact idea of the field to excavate; -to enable if necessary, when the excavation will be ended, to give to the premises the same aspect that they had before the labours; -to position the axis of the excavation, joined with a squaring for the marking out of the founded relics; -to locate some working results independently of the squaring; -to illustrate the publications and the studies that will be carried out at the end of the excavation. The relative location of two neighbour detail points have to be determined thanks to this plan with a planimetric precision of about a decimetre, and an altimetric accuracy of a halfdecimetre. The exhaustive plans of each part of the squaring are then carried out, layer by layer, for an exact (centimetric) location of the buried objects. Topographic equipments or simple measuring rods are used for the planimetric surveys, and a levelling of the excavation field is carried out too, for the altimetric positioning. The archaeologist can also achieve stratigraphic sections of the superficial layers enclosing the evidences of the human existence. The field section is then captured by photography, after having set out a graduate staff against it, put a bench mark number on each layer, and indicated a reference level. (Figure 2) The plans and following surveys should be connected with a wide area coordinate system through the maps made during the prospecting phase, by a classical topographic survey (polygonal traversing based on a geodetic network) or, more recently, by a GPS survey. This task makes sense to link up geographically nearby sites, in order to be able for instance to find potential relationship between each other.

After these localization work, it is required to record the events that occurred during the excavation and to survey the discovered elements. A journal is then written to keep exactly the progresses of the labours, and the objects are traditionally recorded by the following procedures: -archaeological photography, on which a scale (staff or measuring rod put in the principal object's plan) must always appear; -latex or plaster cast, and paper or latex stamping to take impressions of engravings or inscriptions; -handmade measurements and sketches; -field samplings.

Figure 2. Excavation field of a roman forum in Sarmizegetusa (Romania). (photo F. Perdrizet)

In addition to these, some other more impressive methods are today at the archaeologists' disposal. They proceed directly from the evolution of surveying technologies and are principally based on photogrammetry and lasergrammetry. For instance, a computerized solution for the epigraphic survey of Egyptian monuments, including a part based on photogrammetric techniques for the treatment of columns, have been developed in the Computer Aided Design Research Group (GRCAO) of the University of Montreal (Meyer, 2004; Revez, 2004). The laser technology itself, with its performances and its rapidity of acquisition, provides deep changes in the architectural survey methods. The survey becomes more objective, closed to a photographic document, and so the archaeologists' analyses and observations can be carried out once the survey is performed. Likewise than photogrammetrical methods, architectural and epigraphic surveys are achieved in one step, what allow to link the architecture of monuments and the scenes that are engraved in. The results are 3D models of archaeological elements (the architectural parts but also the small artefacts found), sections according to different axes for the layout of plans, orthophotographs from textured 3D models, epigraphic restitutions, etc. (Chazaly, Laroze, 2005).

To conclude this part, we can say that surveying work is an integral part of the archaeological prospecting and excavation processes, because they require location and survey tasks. This work is the surveyor's speciality, but it becomes simplified and the archaeologist achieves it more and more himself. The third phase of any archaeological operation is the inquiry in laboratory, and the next part will show that the new competences of the surveyor allow him to take part as well (and perhaps more soon) to this archaeological problematic.

3. THE POTENTIAL OF COMPUTERIZATION FOR THE MANAGEMENT OF CULTURAL HERITAGE DATA

Archaeological processes give out a large quantity of cultural heritage resources that must be managed in order to profit from them. The fields of application for computer science in archaeology are thus numerous and diverse: field recording, archiving, predictive modelling, combinative studies, analyses of watched facts, data combination and cohesion, etc. To make the most of the computer tools potentialities proves to be necessary, taking into account the quantity of data that are released (difficult to handle efficiently with usual means). Moreover, the treatment of the various data as a whole is required to be able to carry out syntheses, e.g. for the publication. We must then make easier the consulting of excavations archives and the crossing of information, what can be translated in data processing terms by the development of Databases and of Information Systems to handle them.

3.1 The reasons for computerizing archaeology.

An archaeological excavation is destructive by definition, and it is required to memorise what the archaeologist ruins during it. Hence, the excavation's quality depends essentially on the accuracy of the surveys carried out on the field (the recording system must ensure the documents reliability), and on their presentation in the results' publication. From a practical point of view, every person in charge of an archaeological site is faced with some problems explained in Table 3.

speeding up of the recording process of excavated data	because the vestiges have been deteriorating at great speed for years or to avoid to reside in the field more than necessary, e.g. if found relics blockade the site of a new construction
treatment and management of excavation's archives	to preserve it and to organize it at best for the different analyses to be carried out in an optimal way
insertion in the same medium and comparison of data	data which source, type, format can be very various (objects and reasoning, images and texts, etc.), and that must be confronted for classification, dating, comprehension, etc.

Table 3. Problems of archaeologists on a site.

In the archaeological inquiry phase that interests us in this part, the point is to solve the two last difficulties quoted here (some solutions to the first problems have already been given in the previous paragraph). The computerization of processes and data in this scope allows for instance: -to facilitate the access, the control and the handling of the information; -to constitute a digital documentary base and a technical normalized reminder;

-to convey the data (the computer is an essential auxiliary for the achievement of publications and for exchanges with other institutions);

-to avoid that the studies lead to work where the data of each expert, because they are isolated, keeps devoid of a part of their sense.

The possibility to use and revise data synthetically "in deferred time" is an undeniable advantage permitting best results in the source's treatment (more objectivity and more investigation time). Furthermore, an important aim for the computerization in archaeology is the publication of the findings and of the analyses' outcomes. In fact, the lack of reports slows the progression of research and data acquisition processes, whereas it would be encouraged by the integration of perfectly documented materials.

3.2 The knowledge of surveyors for the data management.

Thanks to the progresses of computer science, the training of the surveyor is changing and he becomes specialized in the creation of Databases and in their handling with Information Systems, Geographic in general. These systems are transposable for archaeology.

3.2.1 Databases: The computerization of data in archaeology requires the construction of databases, that consists of the digitalisation of the available resources. The databases systems include the numerous benefits of the computerization, since they contribute to keep the consistency and the reliability of data in time. Accurate and dependable databases of archaeological sites could be valuable for the prospective labours to be carried out on these fields: reconstitution, maintenance, publication, exhibition in museums, etc. They are the "virtual memory" of the site. The most prevalent today in archaeology are for the majority established for the management of sites or monuments' groups at regional or national levels. There are few cases where the database technology is used for the management of documents at a site level (cf. 3.2.2). To construct usable databases, it must be seen notably: -to supply a database enough objective to set up a reconstruction of the past, which will not be purely speculative (no personal interpretations adding directly to the data); -to create a database under the condition to be rigorous and to check that it contains as much information as possible (under different forms according to the later use of the data).

This last point is very significant because the more relevant

information are contained in the database, the more it is interesting for the utilization by the future information system that will be based on this database. The value of the acquired data depends on the ability to extract information from these resources (an information being the addition of data and semantic elements). Extracting information is necessary to reach decisions and to understand the source or the object. Afterwards, it is required to take out the essence of information, that is to say to do a reading of them according to the end towards we work (modelling, interpreting, dating, etc.). To use at best the data and the sources that we have, we will then try to reduce the documentary base to a set of synthetic information or of significant indicators.
To end with, the database will contain an object (or a layer) to which we attribute a number, coordinates, source (identified and documented), qualitative descriptors, relevant documentation (especially the bibliography of the source), comments, etc. From this point, it must be thinking about some other problems: indexation, establishment of thesaurus, categorization, management of the redundancies, knowledge organization (detection of incoherencies), etc. The aim is to carry out a database as clear and full as possible, and exportable to a management system.

3.2.2 Information Systems: Once one or several entire and reliable Databases have been generated, they have to be correlated with an Information System. Most of the time we speak about Geographic Information Systems (GIS), but the principle of the "Information System" can be applied to all kinds of information. The management of the database by an information system provides an enrichment of information, in permitting the immediate confrontation of all sorts of data at disposal: archaeological (and archaeometrical), historical, architectural, geographical, topographical, geological, environmental, etc. Today, the most of these systems are developed for the management of geographical resources. It is probably the lack of a good theoretic environment in which to undertake analyses on the scale of an archaeological site, that limits the use of information systems for the working on of excavated data. In fact, this affects directly the quality of the resources found in the site and the relevance of their archiving. Nevertheless, as said before, the quantity of the collected data prescribes to manage them by means of computer science, and information systems are the best way to succeed in doing this efficiently and to extract of them the maximum of edifying results. A need expressed currently by some archaeologists leads towards a tool that will allow an "exploratory analysis of the data", which have to be fast, effective and flexible, notably at spatial and temporal levels in case of large-scale information systems. The quality of an information system is estimated by its capacity to present information in a useful way, as fast as possible. In fact, considering the project of a person at a given moment and in a given environment, what does matter to him is to obtain a clear depiction of the tools he have at disposal to visualize the documentary base in different ways. An information system is then constructed keeping in mind the need to acquire quickly the best information elements that will give answers to experts' questions, and to make these elements available for interpreting studies. Such a tool must so permit to carry out a real multidisciplinary synthesis of all resources of the database. To extract data from the database, they are put through various types of successive or simultaneous selections, and visualized in tabular form, exportable graphic, three-dimensional model, etc. In all cases, the corpus of the final interesting documents is constituted by gradual refinements of queries (search by keywords, Boolean operators, proximity operators, etc.). For archaeological data especially, the creation of an information system can lead to achieve: -to treat graphically several information derived from very
different kinds of surveys, because a selective superposition could be a precious help for the interpretation; -to combine elements selected in diverse graphs for the carrying out of visualizations in a synthesis plan;
-to present images and their connexions with the concerned texts from the database, to lead to a complex system in which the examination of texts and images would be possible simultaneously.
Data should be reachable through graphical interfaces proposing arrangements that reflect the organization of the documents, and "surfing" in the information could be possible through a succession of various representations.
Having from now on an overview of the new expertises of the surveyor in the scope of data management, it remains to see the advantages of this computerization that could occur for the archaeologists.

3.3. The benefits of data computerization for the archaeologists.

The computerization potentialities explained before involve the idea to perform projects to manage and make use of archaeological data, on a site scale. Some advantages of such projects are mentioned in Table 4.

More durable memorizing of acquirements, what is interesting above all if the site disappear because of new constructions.
Help for analysing and understanding the excavated data of the site, through synthesizing (overview of all available data) and quick confrontations of different types of documents.
Digital restitution of the successive states of the site and modelling of historical evolutions.
Proposal of tools for the working out of reconstitution hypotheses or for the validation of already made reconstructions.
Aid for the dating of elements, thanks to the simplicity of comparison between various data.
Identification of data sources or of objects origins by confrontation of similar documents coming from different archaeological fields.
Conveying the knowledge: the virtual imagery is eloquent and the interactivity with the model is attractive and instructive.
Emphasizing of the site and improvement of the museums exhibitions.

Table 4. Benefits of management projects for archaeological work.

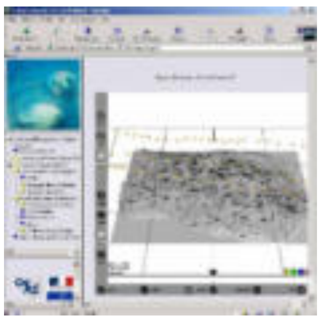

Figure 3. Example of an interactive 3D model linked with a database. (Drap, 2004)

This small listing is only an outline of the numerous new developments, to which an entire integration of computer science in archaeology could lead, and other advances would appear with the fast evolutions of the data processing. An interesting example is to discover in (Drap, 2004). (Figure 3)

4. CONCLUSION

This paper has dealt with surveying and archaeology. These two disciplines are historically linked, however the place of the surveyor in the archaeological problematic is changing. The archaeologist being now able to perform a lot of topographical field work himself (thanks to the simplification of the survey procedures), the surveyor can concentrate on other types of activities. Actually, the management of the great quantity of archaeological data emitted by a site is an important difficulty with which the archaeologist is confronted, and the new expertises of the surveyor allow him to develop computerized solutions to this problem. Increasing the incorporation of data processing techniques into archaeology would permit to simplify, speed up, and complete the possibilities of capitalization of cultural heritage resources. We hope that this should be accelerated on account of progresses of the surveyor abilities. A project for the management and the exploitation of data gathered about the medieval castle of Vianden in Luxembourg is currently in progress, in the context of the Ph.D. thesis pointed out in the introduction of this article.

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