A GIS Solution for Excavations: Experience of the Siena University LIAAM

Vittorio Fronza, Alessandra Nardini, Federico Salzotti and Marco Valenti

Dipartimento di Archeologia e Storia delle Arti – Università di Siena

Via Roma, 56 – 53100 Siena, Italy

e-mails: scarpazi@mac.com, alessandranardini@virgilio.it, freeco@virgilio.it, valenmar@unisi.it

LIAAM website: http://www.archeo.unisi.it/archeologia_medievale/welcome.html

Abstract

It is our intention to present the experience accumulated in the last decade by LIAAM at the Department of Archaeology and Art History - University of Siena, Italy. During these years we specialised in developing solutions managing every kind of information produced by an archaeological project. We work on different scales (from regional surveys down to detailed records of all the finds). All the data is administered within a system made up of three components: different GIS platforms, an alphanumerical database and a media database; these are linked by a system level application called OpenArcheo*, directly engineered and developed at our Laboratory. The basic concepts of our system are the multidirectional links between information types (which allow the user to query and retrieve all the information related to a feature starting from any of the components mentioned above), modular organisation of architecture in order to implement the ever changing variables and detail levels of archaeological research that suit the specific needs of every single project, and of course, user-friendliness making the management of complex data possible to anyone who has a basic knowledge in the use of computers.*

In short, what we try to do is optimise the management of information produced by archaeological projects and allow the archaeologist to have all the different kinds of data at hand in real time. Such a system fits perfectly with the application of landscape and intrasite spatial and statistical analysis tools, allowing us to build predictive models of landscapes and settlements, orientating every campaign of our projects and providing simulations of the parts we cannot investigate.

We also take particular care in editing our web pages (our web-site is made up of more than 1000 pages constantly updated, and it also provides a portal with more than 7000 links; http://www.archeo.unisi.it/archeologia_medievale/welcome.html), 3D modelling and hypermedia production, in order to spread the information we produce to the widest range of people.

Key words: excavation GIS, excavation DBMS, intrasite analysis, Medieval archaeology, OpenArcheo, global archaeological data management

1. Introduction

The Siena University LIAAM (Laboratorio di Informatica Applicata all'Archeologia Medievale – Laboratory of Information Technology Applied to Medieval Archaeology) made its first steps in the field of computing archaeology at the end of the 1980s (regarding the change in our working philosophy, the evolution of the last years and the new frontiers towards which we are heading, see: Francovich 1990, Valenti 1998a, Francovich 1999, the Italian state of art is described in Francovich and Valenti 2000). The target of our experiments, always aiming towards the global running of archaeological data, remains the production of working tools which allows integrated consultation of all gathered data, free of any preliminary interpretations: not only a supporting instrument but a really useful tool for the *in fieri* research. As already stated our working philosophy consists of six main points:

- technology as an instrument of research in the field;
- technology as a recording instrument for lab files;
- technology used to query and investigate the data we have in order to produce knowledge;
- great attention is paid towards any technological innovation on the market;
- the whole process is managed by archaeologists who, without reaching the "know how" typical of computer scientists, acquire a high end user level;
- ability to use the computer as an advanced household appliance, to be ordered (through programming) to perform what we want it to.

Throughout the years we have acquired skills in processing aerial photographs, GIS manipulation of excavations and landscape projects, advanced scanning and editing, 3D modelling, photorealistic rendering, animation and morphing procedures, electronic video documentation, digital photography, CAD techniques, programming languages, multi-media productions, QuickTime Virtual Reality applications, the production of web pages. OpenArcheo, the system of global data manipulation, is conceived through hierarchical recording levels, each of them characterised by different levels of detailed information; at present they can be divided into: macro level (Tuscany), semi-micro level (areas under survey) micro level (excavations).

Our global data management system, called OpenArcheo, is conceived on hierarchical levels, implying different detail classes; we can actually distinguish three different scales: macro or regional (entire Tuscany), semi-micro or local (areas under survey), micro (excavations). OpenArcheo represents an integrated and open solution for the manipulation of archaeological evidence;

thanks to it all kind of data (cartographic, planimetric, alphanumerical, graphical, multi-medial, etc.) can be queried and visualised in a multidirectional way. The system revolves mainly around two fundamental issues: documentation (what kind of documents do we want to obtain?) and the relation keyword (what is the research key through which we want to gather the requested documents?). Let's assume we are working on the GIS of an excavation and have a need to study the ceramics related to the period of the selected evidence: documentation will concern pottery finds, the relation keyword will be the period and the link will originate from the GIS to the DBMS of the excavation.

The usefulness of such a manipulation is clearly perceivable; this is especially true if we take into consideration the multidirectional possibility of the links (any single type of data interacts with all the others), the wide range of information gathered from the macro to the micro scale (that means from a regional view down to the record of a single pottery piece) and the promptness and easiness of the connections. It is a sort of application that allows the best kind of monitoring of the archaeological evidence: that has been our main purpose during the last few years.

Within the creation process of our system we have concentrated especially on experimenting with GIS platforms for archaeological excavations. We have already written about the way we conceive the close connection between information sciences and archaeology, the standards we have been working on, and some aspects of stratigraphical data management (Valenti 1998a, Valenti l998b). At this point we would like to deal with the problems connected with the building of a data model for excavations (as to the more recent LIAAM contribution on the subject see Francovich and Valenti 2000, Valenti in press, Fronza in press, Nardini in press); we will also try to demonstrate how useful a computer can be in the production of information and in the verification of it afterwards (computer as a relevant instrument for research and GIS as a medium to interpret and understand what we come across). The lab experiments have mainly focused on the excavations at Poggio Imperiale in Poggibonsi (SI) where we have been investigating a long-term medieval settlement (see Valenti 1996, Valenti 1998c, Valenti l999a, Valenti l999b). Since the very beginning of the project, in 1991, we wanted to match new investigating strategies and new technological media. One of the main points supported by the Poggio Imperiale project is that the whole excavation is digitally recorded and managed. All the evidence is included within a GIS platform related to an articulated system of files and records; they contain all the information concerning the excavation and allow the development of new interpretation methods and the planning of the enlargement of the excavation and transformation into an archaeological model.

2. Characteristics of the excavation GIS

The GIS management of the archaeological excavations is intended as an instrument of research and not as an illustration of something already completed. Our proposal can be defined as a GIS solution meaning a series of platforms and files, which interact among them and allow the consulting of all the documents through a wide range of interrelations. It is an instrument that allows immediate manipulation of all the data, the building of various information levels in real time, the creation of new questions according to the gathered answers, as well as the formation of predictive and interpretative hypothesis. In order to achieve all that

Figure 1: Poggio Imperiale GIS platform. Area 2: composite plan (updated to July 2000).

we had to create 3 applications and place them in a dynamic relation: the excavation platform, the alphanumeric DBMS (the stratigraphical unit file system, finds, etc.) and the picture and multimedia DBMS (the system of photographic, graphic and movie documentation). This and the OpenArcheo system have made complex questions easier and have also made elaboration times shorter, thus accelerating the construction of interpretative models.

The GIS platform – At the time we started using GIS software (autumn 1995) we had already graphically planned the Poggibonsi excavation within CAD software, and realised that the tool did not suit our needs (Nardini in press). The necessity of being able to work with an open and functional instrument meant, in our intentions, to reproduce graphically the exact situation of an excavation: a vast composite plan, continually updated, formed by non-interpreted graphical objects. This is the real innovation when compared to other experiences; in fact this is beyond a certain logic (well supported by intrinsic characteristics of CAD applications) which considers the digital manipulation of excavation plans as complementary and subordinate to the one of alphanumerical files (figure 1).

The excavation GIS is conceived as a platform containing the recording of all operations and research campaigns conducted on the site. The Poggio Imperiale hill, for example, has been vectorised completely and placed in its landscape and settlement context (figure 2). The main parts of our data are the detailed geological map, the work of the geoarchaeologist Antonia Arnoldus (geological sections of the hill, archaeological probability map, a theory concerning a possible water gathering system), the preliminary investigations over the territory (field walking projects in 1991 and 1992) and interpretation of different scales of digitalised aerial photographs (the cartographic regional aerial photographs, historical sites photographs, photographs from a tourist plane and from a balloon). Eventually the entire excavation and dumping areas in their progressive movement (they are an integral part of the history of the hill) and the stratigraphical data (from humus to the virgin soil), are complete; the reality of the various archaeological levels is fully represented (the GIS base, counting only the 12 hectare extension of the hill, conducts to a census of 60,112 vectorialised elements at the end of 1999).

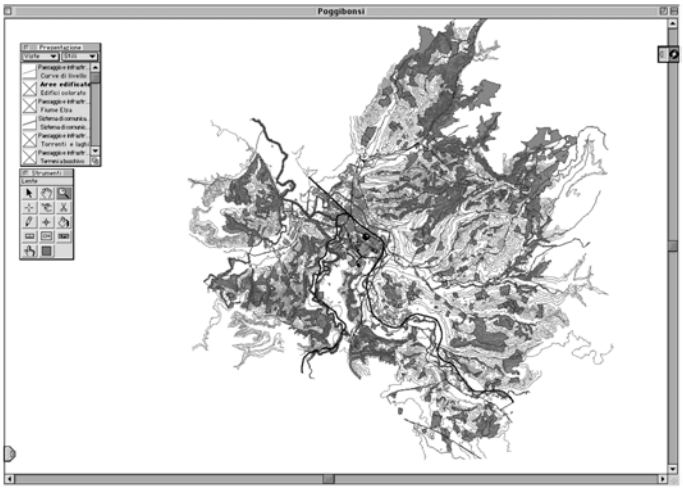

Figure 2: Poggio Imperiale GIS platform. Landscape of the Poggibonsi commune with land cover; in the centre lies the excavated area.

The construction of the "data model" - The choice of software is very important and should not tend to products supported by a rigid structure (like some of the standards for landscape projects; for example ArcView). That is why we have chosen MacMap (made in France), a software programme which allows an *ex novo* construction of data through the creation of a model, organised in types and subtypes, defined both geometrically (surfaces, lines, and points) and graphically. This peculiarity allows to build up a single data base (and not many different thematic layers) where all vectorialised graphs are gathered and classified at the moment of input, according to prefixed logic schemes (which can always be changed).

The data model has been organised in order to gather (in a stratified way) the whole information set of an excavation: the morphology of the site before the beginning of the archaeological work, the non destructive investigation (survey and crop-marks analysis), the excavation, particular research topics (paleopedological survey, geomagnetism and resistance test, anthropological examination of skeleton finds, etc.), future musealisation (project of an archaeological park) and predictive elaboration on the basis of already acquired information. All of this data has been classified into 13 types (for a detailed list see Nardini in press) based on the typology coherence and geometric identity, and avoiding redundancies. The basic concept is grounded on the intrinsic characteristics of the evidence and not on the basis of subjective interpretations. For example, having to vectorialise the road system, it would be incoherent to insert systems already in use and those under planning in different types of the model: they are typologically similar from a cartographic point of view and therefore belong to the same type.

The DBMS (Data Base Management System) - The system of graphical and multimedia files sees the use of databases created for the manipulation of images, films and sounds (in our case Canto Cumulus Desktop Plus); documents are represented in a gallery of miniatures (which can be seen full size with a simple double click) and consist of a descriptive space and a series of keywords and categories (corresponding to precise identifications in our system) which allows for the consultation of different media and subjects. The keywords associated to each record correspond to the number of represented stratigraphical features, the excavation areas, the stratigraphical and the interpreted US definition, the

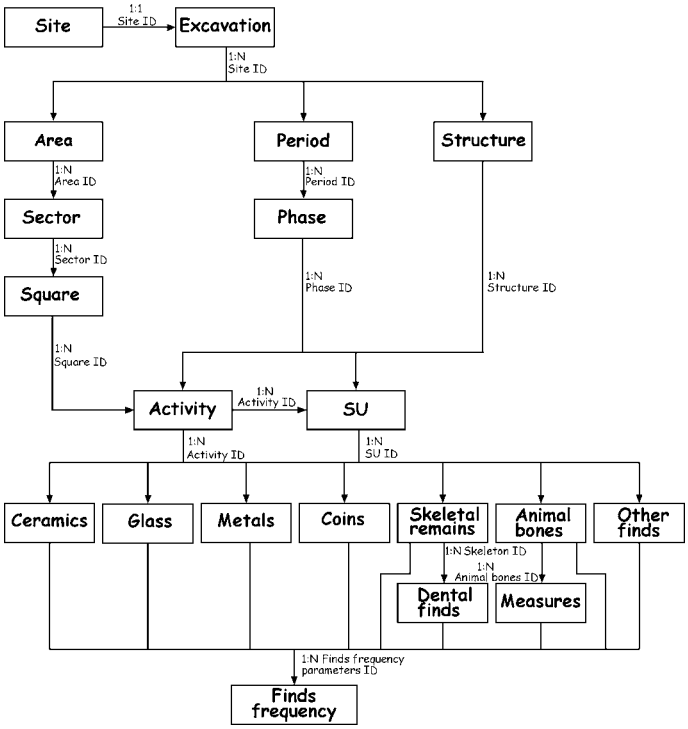

Figure 3: Archaeological excavation DBMS. Diagram of relational architecture.

interpreted structure, the periodisation, etc. So far 5700 documents regarding the Poggio Imperiale project have been recorded (including pictures, movies 3D renderings, QTVR documents, animations).

The alphanumerical database represents a substantial point in developing an efficient solution of comprehensive excavation data management. Quality, usability and availability of information depend heavily on this projectual moment. Our file system was conceived as a hierarchical relational database including detailed stratigraphical and finds records (figure 3). If we consider only the Poggio Imperiale project, 19,425 records (comprehending all different tables) have been entered so far.

Regarding all kind of DBMS applied to archaeology we consider it essential to primarily refer to all of the specific requirements linked to archaeological research, and subsequently elaborate a data model which can join the strict (and often abstract) logical principles of computer science with the possibilities of the hardware/software platforms available (in our case a LAN with a Macintosh server, and commercial DBMS applications largely and easily available). We have to point out that it is sometimes hard for cognitive procedures aiming at the production of historiographical models to match the methods of information science; the problems usually solved by computer analysts concern definitive and irrefutable data, which scarcely need updating. The same cannot be said of archaeological research (Fronza in press). During the planning stage of a database (and, more generally, of a global computer solution), functional for research, we have to be very careful as regards two points: the creation of an open structure which can be integrated at any time with new information types and the precise definition of a detail level in recording data. Not taking into consideration these two aspects might end up with the creation of inefficient or partial solutions. An open structure is, in fact, strictly connected with the very essence of archaeological research. This is often dynamic and evolves according to the

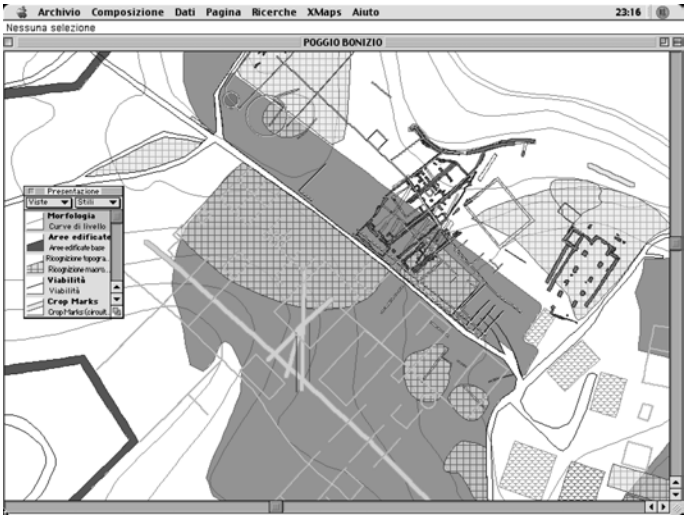

Figure 4: Poggio Imperiale GIS platform. Crossed information levels in order to produce an urbanistic hypothesis of the mid 12th century settlement.

targets of the project; investigations sometimes require a deeper analysis as the excavation goes on. The consistency of the information detail is directly connected with the efficiency of the database; the ideal solution should match the two different needs: detailed study of particular aspects of the project and profitable availability of data.

3. Visualisation of data

The recorded data has been organised into different "views" worked out (elaborated) with the help of visualisation parameters, which can integrate and combine any element according to queries. As we have said before the system is open and temporary views are continuously added to the main views during the use of our platform.

A preliminary view locates and frames the hill of Poggio Imperiale into the surrounding territory and describes its present natural, morphological and monumental features: it shows land use, land cover, contour lines, monumental emergencies, the road system, the new building areas, etc. A further study is recorded and it (through various different colours) shows the different geological phases according to the geological map of Italy. Another layout shows the changes that occurred after the opening of the excavations; the various layers of dumped soil, the location of the huts, and other structures connected with the security of the yard and the consolidation of the found evidence and monuments. Preliminary investigations (surface survey and crop-marks analysis), characterised with different colours and patterns, are organised either in single views or overlapping the wall features excavated during the intensive research in order to verify the correspondence between preliminary data and excavation reality (figure 4). The stratigraphical units (corresponding to three different types: positive stratigraphical units (SU) like surface objects, negative SU like linear objects and characterisations like linear objects) show different colours according to their subtype: a sort of introduction to the vast composite map, from which it is possible to obtain results easily and quickly. Three more views show all the SU according to their main chronological periods: late antique, early and late Middle Ages. Within them some macro views show the single phases of the settlement. Other views show the evolution of the excavation project (the digging areas according to the various campaigns), the perspectives concerning the transformation of the area into a museum (vectorialized, reproducing the master plan of the archaeological park) the paleopedological research (aiming at the creation of a map of archaeological probabilities) and the contextualization in the surrounding landscape (the communal territory of Poggibonsi). The GIS platform, besides allowing a general and detailed survey and analysis of the whole area, the various and different calculations (averages, extensions, distances etc.) the printing of subject maps (periodisation, distribution of finds etc.) allows simulations concerning the structures that have not yet been excavated. This new type of investigation, mainly based on processing excavation data combined with the results of preliminary investigations, gives detailed and interesting suggestions in order to interpret the settlement and orientates the opening of new areas. Other analytical studies concern the early medieval huts (Fronza and Valenti 2000), the early medieval necropolis (Francovich et al. 2000), the distribution of the finds of animal bones (Nardini and Salvadori 2000) and the reading of preserved wall features (Bianchi and Nardini 2000). At present we have just started working on spatial and statistical analysis in order to build predictive models of intrasite settlement patterns, especially dealing with the planning of the small medieval town (which extends on all of the 12 hectares of the hill of Poggio Imperiale; the first results are presented in Nardini in press). This kind of analysis can be considered as the main point of applying GIS technology to an excavation.

References

BIANCHI, G., NARDINI, A., 2000. Archeologia dell'architettura di un centro storico. Proposta per un'elaborazione informatica dei dati su piattaforma GIS bidimensionale. In Brogiolo, G.P. (ed.), *II Congresso Nazionale di Archeologia Medievale*: 381-388. Firenze.

FRANCOVICH, R., 1990. Dalla teoria alla ricerca sul campo: il contributo dell'informatica all'archeologia medievale. *Archeologia e Calcolatori* 1: 15-27.

FRANCOVICH, R., 1999. Archeologia medievale e informatica: dieci anni dopo. *Archeologia e Calcolatori* 10: 45-63.

FRANCOVICH, R., NARDINI, A., VALENTI, M., 2000. La piattaforma GIS dello scavo nella gestione di un'area cimiteriale. In Brogiolo, G.P. (ed.), *II Congresso Nazionale di Archeologia Medievale*: 28-36.

FRANCOVICH, R., VALENTI, M., 2000. La piattaforma GIS dello scavo ed il suo utilizzo: l'esperienza di Poggibonsi. In Brogiolo, G.P. (ed.), *II Congresso Nazionale di Archeologia Medievale*: 14-20.

FRONZA, V., in press. Il sistema di gestione degli archivi nello scavo di Poggio Imperiale a Poggibonsi (Insegnamento di Archeologia Medievale dell'Università di Siena). Una soluzione all'interno della "soluzione GIS". *Archeologia e Calcolatori* 11.

FRONZA, V., VALENTI, M., 2000. L'utilizzo delle griglie di riferimento per lo scavo di contesti stratigrafici altomedievali: elaborazione di una soluzione informatica. In

Brogiolo, G.P. (ed.), *II Congresso Nazionale di Archeologia Medievale*: 21-27.

NARDINI, A., in press. La piattaforma GIS dello scavo di Poggio Imperiale a Poggibonsi (Insegnamento di Archeologia Medievale dell'Università di Siena). Una soluzione all'interno della "soluzione GIS". *Archeologia e Calcolatori* 11.

NARDINI, A., SALVADORI, F., 2000. La piattaforma GIS dello scavo e i modelli distributivi di manufatti e reperti osteologici animali. In Brogiolo, G.P. (ed.), *II Congresso Nazionale di Archeologia Medievale*: 38-45.

VALENTI, M. (ed.), 1996. *Poggio Imperiale a Poggibonsi (Siena)*. Dal villaggio di capanne al castello di pietra. I. Diagnostica archeologica e campagne di scavo 1991-1994. Firenze: Biblioteca del Dipartimento di Archeologia e Storia delle Arti. Sezione Archeologica. Università di Siena, 1.

VALENTI, M., 1998a. La gestione informatica del dato; percorsi ed evoluzioni nell'attività della cattedra di Archeologia Medievale del Dipartimento di Archeologia e Storia delle Arti-Sezione archeologica dell'Università di Siena. *Archeologia e Calcolatori* 9: 305-329.

VALENTI, M., 1998b. Computer Science and the management of an archaeological excavation: the Poggio Imperiale Project. *Archaeological Computing Newsletter* 50 (Spring): 13-20.

VALENTI, M., 1998c. La collina di Poggio Imperiale a Poggibonsi. Uno spaccato di storia insediativa toscana tra tarda antichità e basso medioevo: ipotesi e modelli diacronici (aggiornamento 1997). In *Atti della giornata di studio "I castelli della Valdelsa. Storia e archeologia"*. Miscellanea Storica della Valdelsa 104: 9-39.

VALENTI, M. (ed.), 1999a. *Carta Archeologica della Provincia di Siena*. Vol. III, La Val d'Elsa (Colle di Val d'Elsa e Poggibonsi). Siena.

VALENTI, M. (ed.), 1999b, *Il progetto Poggio (Poggibonsi - SI)*. Guida allo scavo archeologico (aggiornamento 1999). Poggibonsi.

VALENTI, M., in press. La piattaforma GIS dello scavo nella sperimentazione dell'Insegnamento di Archeologia Medievale dell'Università di Siena. Filosofia di lavoro e provocazioni, modello dei dati e "soluzione GIS". *Archeologia e Calcolatori* 11.