Reconstructing Sites and Archives: Information and Presentation Systems at Troy

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Abstract

As a result of more than a hundred years of archaeology at the legendary site of Troy and in the surrounding landscape (north-west Turkey) an immense amount of information has been excavated, recorded, and re-buried in a huge archive consisting of a variety of documents (notebooks, plans, drawings, photographs), computerised data (databases, CAD plans, digital images), and a library of printed publications. Any use of Information Technology (IT) in this context has to serve the practical needs of a large-scale, still ongoing, archaeological field project: documentation of excavations, archiving information, research and analysis, publication and presentation of results for audiences ranging from archaeologists and scientists to the wider public.

Presentation of results has been accomplished by means of 3-d reconstructions built into a Virtual reality (VR) presentation system. Research is now being supported by an information system integrating existing and new databases with Geographic Information System (GIS) applications. This is linked with other software where needed. Two examples briefly described in this paper are the analysis of stratigraphy combining GIS, databases, and a Harris matrix program, and GIS mapping of archaeological sites and palaeolandscapes with the help of high-resolution georeferenced satellite images. GIS is also used in the planning of a national park which will protect at least some of the archaeological sites from further destruction.

From the experience of the author, technology does not seem the limiting factor in archaeological computing. Two other issues are much more important. First, concepts and contents of presentation and information systems: the translation of archaeological methods and work processes into data structures and software procedures. Second, social constraints: the acceptance of IT by decision-makers and within organisations, the level of computing skills, and the availability of funding.

Presentation System

Faced with the complexity of the tasks briefly outlined in the abstract, it seems tempting to take a shortcut into a fanciful world of 3-d reconstructions and Virtual Reality (VR) to save oneself from despair, which I admit we did on a grand scale during the past two years (Project "Virtual Archaeology-TroiaVR" supported by the German Federal Ministry of Education and Research; consortium under the direction of ART+COM AG, Berlin; detailed descriptions in Jablonka et al. 2003 and at http://www.uni-tuebingen.de/troia/vr/). For use at museums and exhibitions reconstructions of three main phases of Troy and the surrounding landscapes were put into a VR presentation system that can be used to give visitors real-time tours of Troy at three different points in time. Reconstructions are accompanied by context information (plans, texts, images of finds and excavations to show the difference between reconstructions and reality, time line). The system was part of an exhibition on Troy in Germany (Bundeskunsthalle, Bonn).

As archaeologists we need to communicate the results of our work to the wider public. After all, most of us are being paid from taxpayers' money, and it will certainly be appreciated if we can offer an interesting and beautiful experience especially appealing to younger people in return. Virtual reality systems can communicate and present the results of archaeological work. At least archaeologists working for museums or exhibitions should therefore make themselves familiar with content and technology of presentation systems.

A by-product of our work on a presentation system was a still growing library of 3-d reconstruction models which can and have been used to generate images, animations, multimedia content and TV footage (Figure 1 shows an example). Assembling 3-d reconstructions also helped archaeologists to understand excavation results. Students working on the project could acquire skills which might improve their chances on a tight job market.

Towards an Archaeological Information System

Even the non-specialist will ask at some point on what actual information our 3-d reconstruction models are based. Reconstructions are visual interpretations of excavation results. Obviously, these results have to be brought together in some kind of information system. Such a system can be defined as a non-redundant collection of all information pertaining to a certain subject, with procedures to search, sort, filter, analyse, combine, and retrieve this information.

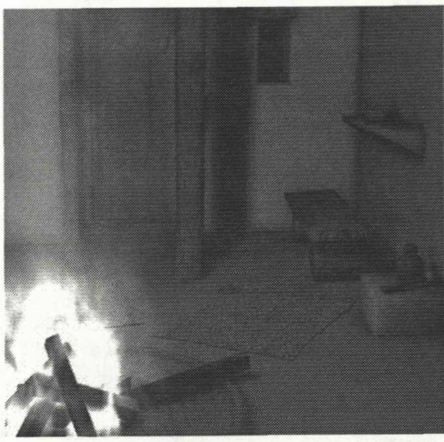

Figure 1 3D reconstruction example for VR presentation (interior of Early Bronze Age building)

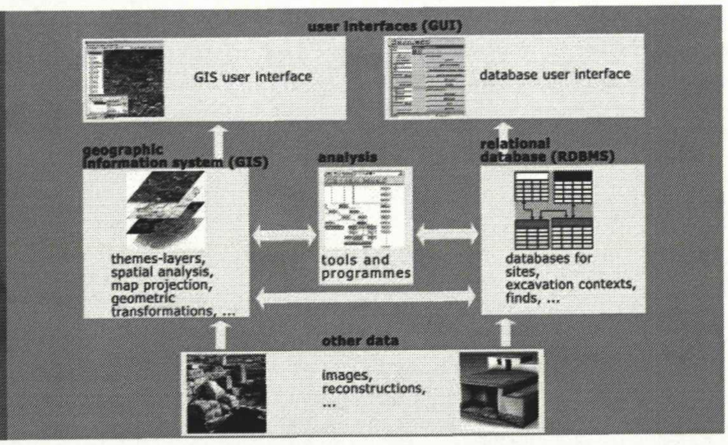

Figure 2 Information system for Troy, system components

From the point of view of contents such systems should at least cover what has been termed "the research archive" (English Heritage 1991, Phase 4), with added capabilities for the acquisition and analysis of data. Since existing examples are carefully studied by those who design new systems we can observe an evolution of best, or at least, common, practice. The key step in the development of such systems is the translation of archaeological concepts into data models. To bridge the gap between excavations, finds, pits and postholes on one hand, data and software on the other, seems bold enough a step to deserve more than the few words it is usually given.

On the computing level, the architecture of an archaeological information system seems fairly straightforward. Looking at archaeology, we see maps or plans, and catalogues or lists, with illustrations. We note that almost everything from sites to finds has a spatial aspect. In fact, archaeology mainly deals with matter distributed in space and time by past human activities.

We can thus design a system with a spatial and a conceptual point of entry, or GIS map and database form user interfaces (Fig.2). The data are stored in a GIS and a relational database (RDBMS). To this tools for analysis (finds statistics, stratigraphy) are added. Non-spatial and non-(alpha)numeric data (images, reconstructions) can be stored separately and hyperlinked to the GIS or database. In this way, all kinds of data can be combined to produce different kinds of output (for printed or digital reports, maps and plans, visualisations).

The system can be implemented using standard software, in our case ArcGIS 8 and MS Access, combined with existing archaeology software (e.g. WINBASP for finds statistics and stratigraphy). Computing skills needed are at the level of simple application programming (SQL, Visual Basic for Applications) to customise applications and transfer data between different software and file formats. The use of standard software should make it likely to find archaeologists who have the technical skills to manage and develop the system, or are willing and able to learn them. Several examples of similar systems have been described in the literature. Lock (2003), Wheatley and Gillings (2002), and of course numerous case studies published yearly in the proceedings of the CAA conference are good starting points. Burrough and McDonnell (1998) is an excellent source on GIS.

Modelling Archaeological Information

Publications on archaeological computing tend to focus on technical aspects. The conceptual work before or behind a given technical solution is rarely made explicit. Many systems which may be termed "archaeological information systems" have been and are being developed mainly for practical use in rescue and contract archaeology (examples in Lock 2003:78-123, CAA conference proceedings; an excellent German example can be found at http://www.arc-tron.de/).

As a first stage in this modelling process, we can identify the following semantic categories in archaeology:

Representations of real-world objects: landscapes, sites, excavation contexts (layers, pits, ruins, ...), and finds.

Conceptual abstractions: time, chronology, stratigraphy, classifications and typology.

Products of work processes: excavation recording systems, catalogues, reports, plans, archives, bibliographies.

The properties of each of these objects can then be described in terms of different data representing it (measurements, textual descriptions, coded values, images, geometry, ...), the connections (interfaces) it has with other objects, and methods used on it (order, query, write report, calculate statistics, draw map, ...). For example, landscapes - sites - excavation contexts - finds are obviously connected in a hierarchy. Different classifications (or typologies, as archaeologists may prefer to call them) can be a property of finds or excavation contexts. Chronology will consist of calendar dates, procedures to calibrate C-14 measurements, and lists of periods or phases. These descriptions can be formalised using tables to note the properties of each object, and diagrams showing connections between objects. The process resembles concepts used in object oriented programming (classes, interfaces, class hierarchies).

The resulting data model should consist of few large objects that could be implemented as separate (but connected) database or GIS applications, thus reducing the complexity of the system by a "divide and conquer" strategy. In the case of Troy, these main objects are: landscapes, sites, excavation contexts, finds, chronology, bibliography, archive, administration. Classifications (typologies) are treated as properties of other objects (e.g. sites can be burials, settlements, ...; finds can be pots of type C21, and so on). As work continues and the system grows, different or new parts and combinations of these objects or modules can be developed and used.

Details of different excavation recording systems, as well as particular technical implementations, can be separated from the data model. Starting with real-world objects or archaeologically meaningful concepts should ensure that we arrive at a meaningful representations of our data and the tasks we wish to accomplish. Ideally, analysis of similar problems should lead to similar solutions, and information systems designed for different projects should in the long run converge into common standards. It seems worthwhile for archaeologists to devote time and effort on this conceptual side of computing rather than hunt for the latest technology, or concentrate on technical details. A comprehensive description of an archaeological information system is beyond the scope of this paper. I should therefore like to give two short examples putting the above considerations into practice.

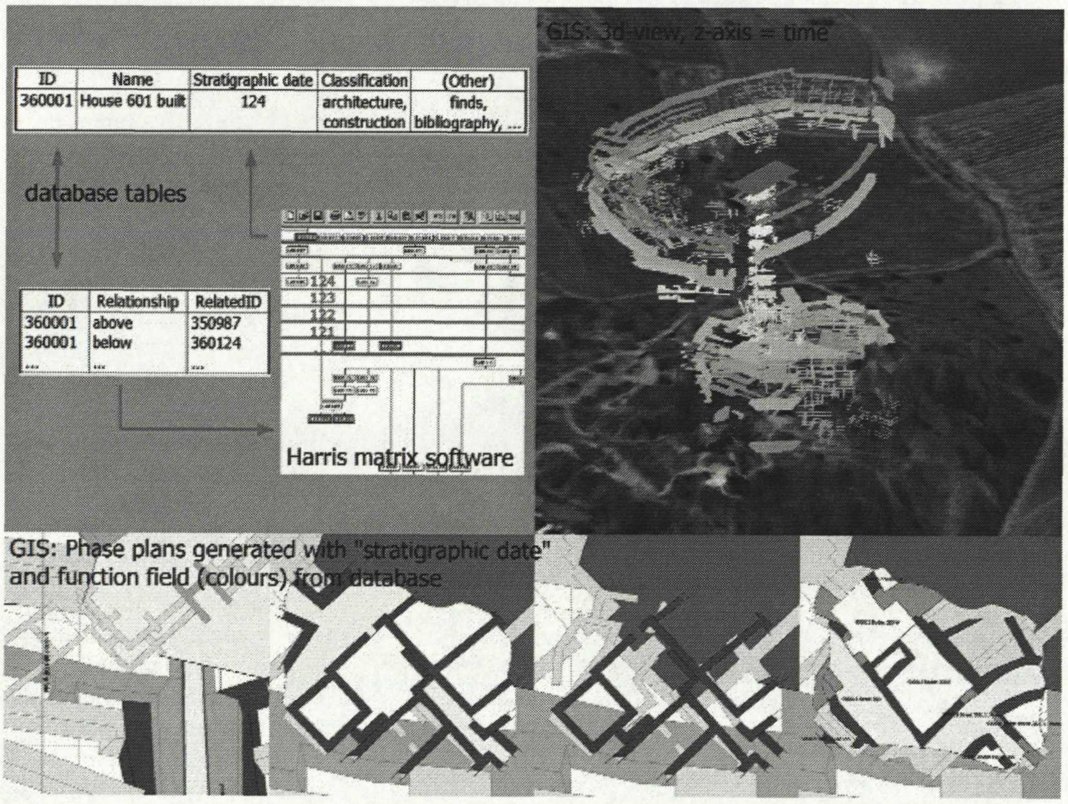

Figure 3 Stratigraphy example: Database tables and stratigraphy program, pseudo 3D display of layers (old=bottom to young=top), automatically generated GIS-phase plans (colour: functional classification from database)

Example 1: Stratigraphy

Troy consists of up to 15 meters of settlement deposits. Thousands of structures (layers, pits, surfaces, buildings and so on) can be identified and must be brought into a sequence based on the relationship of neighbouring structures. In other words, a stratigraphy has to be derived from observations recorded during excavation or from the study of published or unpublished information (plans, section drawings, textual descriptions). Since the theory of archaeological stratigraphy is well understood (Harris 1989) and has been implemented in several computer programmes (e.g. Gnet, HARRIS, ArchEd; now also Stratify, see Herzog, this volume), stratigraphy can easily be modelled (Fig.3). In fact, the method applied here has already been described by Alvey (1993).

Two database tables hold data on excavation contexts and their stratigraphic relationships. Contexts are represented as plan or section drawings in a GIS linked with the database table via a unique identifier. A procedure (written in Visual Basic in the MS-Access database environment and run by clicking a button on a database form) then performs the following steps to calculate the stratigraphy: 1.) export data on context and their stratigraphic relations into the format needed in step 2; 2.) run a Harris-Matrix-programme (Stratify); 3.) get the vertical position (line number) of each context from the graph ("Harris Matrix") generated in step 2; 4.) for each context, write this number into a field called "stratigraphic date". With this number an ordered sequence of all contexts can be produced, finds linked to excavation contexts can be assigned a date, and the GIS can draw phase plans, sections with layers numbered according to their position in the sequence, or pseudo 3d-representations of time mapping contexts from low=early to high=late. By visual inspection of phase plans or phased section drawings errors or gaps in the stratigraphy are easily detected. The stratigraphy will be updated, new phase plans, or catalogue descriptions of excavation contexts will be produced automatically as new contexts or stratigraphic relations are entered (note that the stratigraphic position of all contexts, and all finds associated with them, will change whenever new information is entered or existing data are corrected or refined). At a very complicated site like Troy with an excavation history going back to the days of Heinrich Schliemann (1822-1890), one consistent, dynamically growing stratigraphic sequence can thus be constructed and maintained as work continues.

A disadvantage of using GIS to work with stratigraphy is their poorly developed capacity to handle three-dimensional data. Most existing excavation data are also two-dimensional (plans and section drawings) - archaeologists are therefore used to work within the "2.5-dimensional" space typically offered by GIS systems.

EXAMPLE 2: ARCHAEOLOGICAL SITES IN THE TROAD

During the ongoing fieldwork at Troy the landscape surrounding the site (the Troad), has been extensively studied. To model a whole landscape turned out to be easier than expected. All that was needed was a rather straightforward GIS application connected to a sites database and auxiliary databases that are also used by other parts of the information system (bibliography, lists of and links to archive material - mostly scanned images, chronology).

Space, or a landscape, is conveniently represented as a set of thematic layers in a GIS system that will also provide procedures needed to manipulate these data (map projections, transformations, georeferencing, spatial analysis). Currently this system contains the following themes: surveying points, GPS locations of archaeological sites, scanned topographic maps, scanned historic maps, digital elevation models, vector data base maps, IKONOS and Landsat satellite data, geological maps, locations of palaeogeographic sediment cores, reconstructions of palaeogeography for different points in time, and detailed representations of archaeological sites (see below).

Time can be represented in GIS or database systems in several ways. Any spatial or other data can carry time information as an attribute field (periods or phases, calendar years, time spans as years from-to). Periods, phases, or whole systems of relative chronology, can be calibrated against each other simply by adding "from" and "to" fields (in years). This information is localised in a chronology database shared by all parts of the information system (e.g. finds and excavation contexts databases). Palaeolandscape reconstructions and historic maps can be displayed as "time slices" by the GIS, if desired, with other data carrying time attributes (e.g. a selection of archaeological sites).

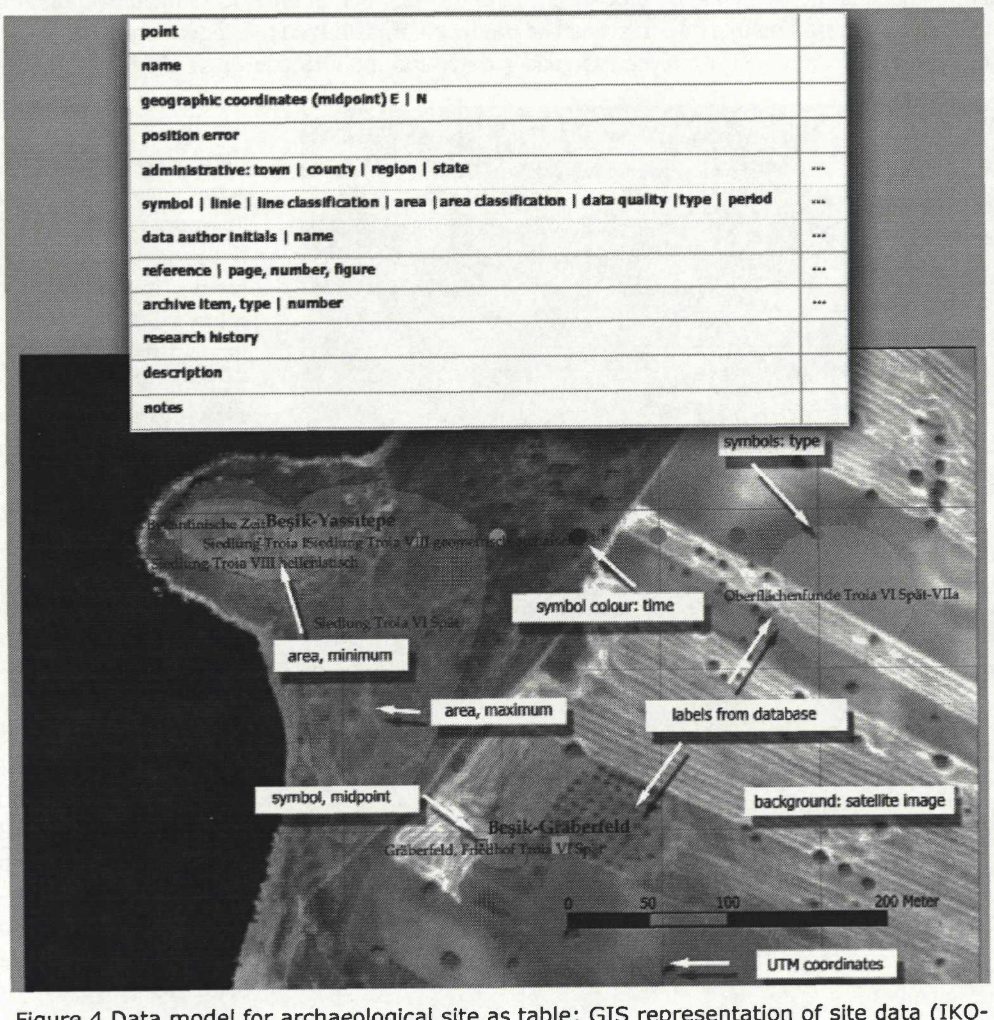

Figure 4 Data model for archaeological site as table; GIS representation of site data (IKONOS satellite image courtesy Compton J. Tucker, NASA and Space Imaging, Inc.)

Information on archaeological sites is kept in a database: location of site midpoint (from GIS mapping) and accuracy, modern administrative units the site falls into, research history, description, notes, contributor(s) of data, reference(s) (link to bibliography database), archive material (plans, photos: link to database of archive materials and images), type (e.g. settlement, burial, ...) and period (e.g. Bronze Age, Roman, ...). Since sites can consist of remains of different types belonging to any number of different periods, an unlimited number of such type-period pairs can be associated with one site. By linking this database to a GIS, sites can be mapped in several ways: As site midpoint (with site name); as a row of symbols next to the site midpoint (different symbols for types, different colours for periods present); as multipoint (scattered remains), line (e.g. roads), or area features (different areas for certain or reconstructed site extents) for each type and period with known extent present at a site. In the field, sites can be mapped on printouts - fairly easy with 1m-resolution satellite data showing every tree. GPS readings can be taken in the field and plotted. It is easy to re-visit sites even in difficult terrain by loading their coordinates into a GPS and using a "go to" function to find them.

Figure 4 shows a data model of an archaeological site as table and GIS representation of sites with a georeferenced satellite image as background map.

Conclusion

A century of excavation has reduced the settlement mound of Troy to a heap of rubble resembling a stone quarry more than anything else. Research results have been re-buried in a huge archive that has become as difficult to access as excavation at the actual, multi-layered and badly preserved site can sometimes be. From our own, still ongoing, fieldwork, we have several thousands of hand-drawn plans, hundreds of notebooks, a collection of more than 40,000 photographs, and data that may be anything from texts, a maze of databases, scanned images, CAD-plans, to satellite data - not to speak of three sets of information from earlier excavations under the direction of Heinrich Schliemann, Wilhelm Dörpfeld, and Carl W. Blegen. Traditional, comprehensive post-excavation analysis and publication of research results at the site and in the surrounding landscape (including descriptions, plans and stratigraphy of all excavation contexts and complete finds catalogues and statistics) will be very difficult, if not impossible due to the size and complexity of the task.

Information on landscape, archaeological sites, excavation contexts, and finds, is therefore being integrated in an information system. This is possible using customised standard software (GIS and databases). Structure and content of such a system deserve more consideration than the technology used. It is important to translate concepts and methods of archaeology into formal data models and procedures to create systems that serve the needs of archaeologists, and will be understood, accepted and used by them. Such decisions about the ways archaeology is represented in computer systems - often tacitly and implicitly made by specialists - will certainly shape the future of the discipline. Once an information system has been set up, it should be possible to publish its contents either on CD/DVD or online (for examples see Clarke et al. 2003, the Electronic Cultural Atlas Initiative, this volume and http://www.ecai.org/).

Apart from being an object of academic research, Troy, and archaeology in general, is very popular. To serve the wider public, a VR presentation system showing reconstructions of the site with accompanying context information has been created. Ironically, the spectacular results obtained within a short time in our VR reconstruction project helped to create an awareness of the possibilities of archaeological computing even with colleagues who had sceptical views both on the use of computers in archaeology and 3-d reconstructions. The project also made it possible to obtain resources needed to make progress with the information system. Cultural, sociological, and economic factors - the acceptance of IT within organisations, the level of computing skills, the importance ascribed to computing in teaching and research, and the availability of funding for the acquisition of equipment and the recruiting of staff - will be at least as important for the success of IT projects as the technologies used (Lock 2003:263-268).

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