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A MULTI-DISCIPLINARY APPROACH FOR RESEARCH AND PRESENTATION OF *BRACARA AUGUSTA*'S ARCHAEOLOGICAL HERITAGE *

1. Introduction

The adoption of new technologies to help research, management and presentation of archaeological past is a natural feature that resulted from the necessity of managing a large amount of data and also from the quick evolution of the new technologies, increasingly adaptable to the processing and generation of archaeological information.

Considering the development of new technologies in the last decades one can consider that the first important interface between archaeology and computer science was given by the technology of GIS (Geographical Information System) since it links alphanumeric information with graphics enabling spatial analysis and control over field data (Allen *et al.* 1990).

Sophisticated product of the recent technological development GIS is now a working platform currently used by archaeologists, although the experiences with its utilisation remain mainly in the field of archaeological management inventories and in the study of landscape archaeology once it is useful for terrain representation and a tool for modelling and predicting the past, creating new data in the form of new map overlays (Harris, Lock 1995). Nevertheless, GIS is also a powerful instrument to manipulate excavation data with obvious advantages when we deal with large amounts of information and long time historical sequences as it happens in urban archaeological projects.

Once spatial representation of data is built a natural evolution of using new technologies is to interact and manipulate spatial information in virtual environments exhibiting reconstructed models. This technology applied to archaeology, although being very recent is a powerful instrument. In fact it changed completely the traditional representation of the past, since it restores the fourth dimension to archaeological sites: the time.

To make this possible a multi-disciplinary approach is necessary, which starts with the interpretation of qualified data by archaeologists, the transformation of bi-dimensional data into tri-dimensional models, recreated by architects, to finish with the creation of virtual models with the introduction of the real time dimension, giving the possibility to move and interact inside the spaces.

* In memory of Carlos Dantas Giestal, who died last September and who was responsible for the SIABRA design.

This paper aims to present an archaeological information system and multimedia applications used to store, manage, query, display and present archaeological data provided by the excavations carried out in the town of Braga, Portugal, after 1976, related to the "Urban Rescue Project of *Bracara Augusta*", supervised by the Unit of Archaeology of Minho University.

The implementation of the archaeological information system was supported by a research Program of financing of F.C.T. (*Fundação para a Ciência e Tecnologia*), and was developed between 1997-1999. After the end of 1998 experiences with virtual modelling of Roman public and private buildings have shown to be a natural and consequent improvement of the information system created.

2. The archaeological problem

2.1 *The case study:* Bracara Augusta. *Historical background*

Bracara Augusta was one of the three urban foundations held by the emperor Augustus in the NW of Iberia at the end of the Cantabrian wars (19 BC). All along the 1st century the town becomes an important administrative and economic centre, served by a network of roads, once it was a key access point to NW from the South of the country (Martins 1999).

Capital of *conventus* and later on capital of the province of *Gallaecia*, created by Diocletianus, *Bracara Augusta* developed a considerable urbanised area (48 ha) which was fortified at the end of the 3rd century by a large wall with semi-circular towers.

After 407 AD *Bracara Augusta* became capital of the Sueden kingdom. Several attacks of Visigoth and Muslim were responsible for the abandonment of considerable areas of the town which were transformed into farms, being the medieval nucleus of Braga restricted to the NE quarter of the Roman town.

2.2 *Archaeological research and the management of data*

A program of urban archaeological research in Braga started only in 1976 with the implementation of the "Project of Rescue of *Bracara Augusta*" and the creation of a special team responsible for its management. After 1976 a systematic field and lab work was developed by the Unit of Archaeology of Minho University in collaboration with the Museum of Archaeology D. Diogo de Sousa (after 1980) and the Municipal Archaeological Services (after 1992).

Rescue excavations and research undertaken in the last 24 years provided a considerable amount of data related to urbanism, architecture, social and economic life of the town. The large thousands of graphic records and alphanumeric information obtained in the field, with different degrees of performance and importance created important constraints to the researchers, and enabled a quick use of them, both for academic or public diffusion.

In order to overlap such constraints a computer system was designed to manage on line all archaeological data available. Centralisation and organisation of records, easy access to them, as well as the possibility to visualise information in a geographic support were the main aims of the system created in 1997, named SIABRA (**S**istema de **I**nformação **A**rqueológica de **Bra**cara Augusta). It is a GIS project designed to manage geo-referenced data, which can be manipulated at different scales, currently used to research and diffusion.

2.3 *Archaeological information and media diffusion*

Although the recent interest of the public for the past, the archaeological record is not easily understandable by non-specialists. In fact it is a sophisticated information collected with scientific procedures which must be deciphered by academics and transferred into discourse and images. The transformation of archaeological discourse in a product available to a large public requires a set of stages of treatment which are in contradiction with nowadays pressures to produce information and representation of the past, once it is part of our social heritage.

The creation of 3D models and the development of virtual environments are important issues to answer the necessity of producing quick, useful and qualified information supported by the archaeological record for cultural and edutainment uses.

In this sense it is the intention of the team responsible for the project of *Bracara Augusta* to develop VRML tools linked with SIABRA to produce models of the buildings and a general virtual reconstruction of the Roman town.

3. The solutions: a multi-disciplinary approach to study, manage and represent archaeological data

3.1 *Data organisation. The SIABRA project*

SIABRA (Giestal 1998) is a working geo-referenced platform which joins alphanumeric and graphic archaeological information, designed to perform different research task, to help current rescue work and the management of the project and to facilitate dissemination of *Bracara Augusta* information.

3.1.1 The technological approach: hardware and software

The diversity and specifics of the archaeological information forced the adoption of a flexible structure, regarding assignments as functions, such as suited peripherals of data acquisition and computers with massive storage and processing capacity. The chosen platform was Windows in order to facilitate the access to a more advanced and "mature" software, within Geographic Information Systems (HEYWOOD 1997).

A local network was constructed, linking in a functional way, the several tasks of the project. It has been also foreseen a link to the D. Diogo de Sousa Museum and to the Cabinet of Archaeology of the City Council of Braga, the other institutions linked with *Bracara Augusta* Project.

The job posts of introduction and consultation are basically compound by computers with Pentium processors, Windows NT 4.0 operating system and displays of 17 inches, complemented by peripherals of geographical data acquisition (digital tables and scanners), and peripherals for saving this data (Zip Drives of 100Mb and Arcserve Tape of 30Gb). In addition to the job post of introduction and consultation, the advanced management and research (graphical handling) is executed in Intergraph TD300 and TDZ computers with memory and processors sized to the required functions. The server *Bracara_Augusta*, a Compac Proliant 6000, contains the repository of all information treated and is the unified element of all project information, through the GIS and respective links to co-operating institutions.

The quantity and complexity of the information to be treated demands a robust and reliable management software of databases. In our case, the choice was the Oracle Database Management System with SQL as query language and the Modular GIS Environment – MGE of Intergraph (RAY, FRASER 1997), supported by Bentley's CAD system.

3.1.2 The formal approach: SIABRA

The evaluation of the archaeological information of *Bracara Augusta* has enabled the consciousness of its data diversity and extension, embodied in a diverse set of documents: field notebooks, reports, publications and photo and design archives, allotted currently between the three institutions involved in the project. Since it was assumed that all information should be treated, it was necessary to classify and organise the data, accordingly to its nature. On the other hand this information needs to be spatially represented, since each excavated area is itself a spatial informative unit and a fragmented part of a spatial totality (the city).

The executed job approached diverse perspectives of the city, comprising several scales that falls up above the city and its surroundings as a whole, or on some parts of it, as it is the case of the archaeological intervention zone, or still above the finds in the subsoil, that can be defined by a point of a finding. Each scale above under consideration evolves different conceptual related and geo-referenced entities.

Data categories

Alphanumeric data include different sorts of textual and numeric information, such as descriptions, identification numbers, altitudes, measures obtained in the excavations. This data is inserted in the database in specific files organised on the base of different attributes.

Graphic data is organised in a *mapoteca* related to database including site plans (1:1000 to 1:500), detailed plans of monuments and buildings (1:100 to 1:20), sections (1:20), photos, videos and other drawings obtained in the excavations. This information is introduced in the system by digitalisation using MicroStation or AutoCAD.

Text files related to the sites excavated provide information about them. They are organised in two main categories: administration processes give information about excavation permissions, classifications, etc; documents include reports, publications and other sort of texts connected with the study of sites.

The cartography constitutes another category of graphic information which include different types of charts of Braga, in different scales, on which archaeological field data of excavations can be represented.

Scales and Entities

– Macro scale: the city and its surroundings

Macro scale space of observation is represented by the area occupied by the Roman town of *Bracara Augusta*, limited by the late wall and by the known Roman cemeteries. Nevertheless, Roman towns could not be considered outside its immediate surroundings where activities and buildings are supposed to be found closely linked to town life. The cartographic base for the representation of this entity is a modern chart of Braga with altimetric and urbanistic information. Another chart from the 19th century, previous to the great urbanistic changes of the town is also used to represent the urban organisation of the Roman town.

– Middle scale: the archaeological areas

Middle scale is represented by the excavated areas of the town, or by areas where observations have been done or finds have been found. Archaeological areas are geo-referenced in macro-scale, being defined by an orthogonal co-ordinate system used for excavation proceedings. The archaeological areas are nuclear entities of the SIABRA once all data is related to them.

– Micro scale: the trenches

Micro scale is related to trenches units of excavation with different dimensions inside which we are able to identify stratigraphy, structures, artefacts, ecofacts and relations between them.

– Nano scale: the artefacts

The lower scale of spatial observation is done by the individual and tri-dimensional position of artefacts.

4. Virtual environments as a representation of the past

Virtual environments are a very significant and important step forward in a more natural human-computer communication, enabling an easy-to-understand presentation and a more intuitive interaction not only with complex data, but also with a very huge amount of data.

4.1 *Brief introduction to virtual environments*

Virtual environments are real-time interactive graphics with three-dimensional models, producing the sensation of immersion in the virtual worlds and direct manipulation with data.

An important feature of virtual environments is realism. The realism of a scene is not achieved only with the careful and accurate modelling. The realism depends on believable appearance and simulation of the virtual world and implies also the natural representation of its participants. The realism in the representation of the participants involves two fundamental elements: believable appearance and realistic movements.

There are two main aspects that contribute to the creation of realistic images: the rendering and the texture mapping (Ofek *et al.* 1997). A good rendering naturally depends on the global scene illumination, on the correct computing of all polygons normal and on the triangulation of the objects that compose the virtual world. Besides the geometry that is associated to the rendered model, a high-quality rendering demands a precise definition of the materials that compose the model and a texture mapping on the different surfaces of the model. The textures are mainly from photos, although it is sometimes necessary to produce artificial textures. These have the disadvantage of being too regular and "clean". On the other hand, the textures that are produced from photos have also some disadvantages:

– They depend on the lightning conditions when the picture is taken.
– They are captured in perspective and so they are distorted.
– The image quality might not be sufficient.

So, it is always necessary to perform a post-processing of the texture, after digitising it.

During the creation of a scene that will be presented in a virtual environment it is extremely important to consider hierarchical information. This enables the interaction with individual objects at different levels. The object hierarchy is also used to speed up the rendering process of a scene, applying level-of-detail (LOD), visible volume decomposition or view culling mechanism (Shade *et al*. 1996).

Virtual environments have been, in the last years, the ideal answer for situations where immersion, inter-activity, manipulation and co-operative work (Rowell 1997) are fundamental, and they are already used in a variety of areas like (Encarnação *et al.* 1995) architectural design, urban planning, medicine, scientific visualisation, training, virtual prototyping.

Archaeology is an extremely interesting application field for virtual environments. Through new virtual environment techniques it is possible to recuperate patrimonial heritage which is, in some situations, in extremely bad state of conservation or completely disappeared. The archaeologists and historians have now the possibility to realise their research activities with virtual models, preventing the archaeological founds from being excessively manipulated.

4.2 *Virtual environments in archaeology*

Virtual environments in archaeology combine the time-honoured techniques of conventional archaeology with 3D computer graphics, to bring new life to the archaeological heritage. Rather than trying to describe an excavated site using words or rough sketches, the researcher can share his discoveries by showing the entire three-dimensional reconstructed scene and explore it interactively. As new information becomes available, the virtual scene can be updated with the new data.

Virtual environments have several advantages in archaeological research. The archaeological reconstruction, using most of the geometric modelling and computer graphics techniques, is a helpful research tool if the models are accurate. The accuracy is always an underlying goal of any archaeologist. Therefore, it is important to invest resources to obtain technical accuracy, to preserve and convey subtleties that might otherwise be lost or forgotten to future generations that rely on these models (Sims 1997).

An archaeological model enables the researcher to isolate discrete segments of the structure and to look at several elements from a certain period or even to combine different periods. It is always possible to separate the objects that still exist and what is hypothesised in virtual model, and to identify the objects by age and location, using e.g. different colours.

The work of archaeologists is often conditioned to weather and lighting conditions. One of the advantages of using virtual environments together with classical methodologies is that the archaeologists are not limited to the physical space. This means that it is possible to analyse the archaeological founding out of the archaeological intervention area in a building where the weather and lighting conditions do not influence the archaeologists work.

By manipulating the remains they could sometimes get damaged. Using virtual environment technology this will not happen, because the user will deal with virtual objects that cannot get broken. It is also possible to manipulate very complex and heavy objects that are difficult to manipulate in the real world. On the other hand, since the manipulation of the remains gets very simplified, the archaeologists are able to easily combine the structures for a better reading of the founding. This is a very important help since it is possible to recreate, at the very beginning, the environment of a monument as it was and use high quality photo-realistic images in real-time.

Besides the importance of the virtual reconstruction of the archaeological structures, the virtual reconstruction of ecosystems is also very important for archaeologists. The virtual paleo-environmental reconstruction, not only for working purposes, but also for information diffusion to the public in general, is of extreme importance for understanding the past.

VRML, that initially permitted the creation of virtual worlds with a very limited interactive behaviour, enables now a greater interaction with the objects and introduction of 3D sound as well as video sequences (Hartman, Wernecke 1996). There are sensors that detect movements and actions of the user, generating events that can be transmitted to the object and change their status. The time-sensors enable the control of everything that is related with time, from alarm clocks to animations. Another important feature is the collision detection that enables solid objects to behave like in the real world. So, VRML is a powerful language to create really interactive virtual worlds with multimedia resources. VRML is also very important because virtual archaeological sites can be made available on the Internet. This allows students, academics and curious public all over the world to have access to the information in a form that is easy to understand.

4.3 *An example of archaeological reconstruction in* Bracara Augusta

The following three pictures are two examples of the virtual reconstruction of a public (Fig. 1) and a private Roman building (Tav. XVI, a-b), respectively, carried out at the UAUM and regarding two archaeological sites in Braga.

The virtual reconstruction of archaeological sites is only possible due to a multi-disciplinary team that must be composed by, at least, archaeologists, architects and computer scientist. So, the virtual reconstruction depends on the enormous research work and interpretation performed by the archaeologists, on the reconstruction that is carefully elaborated by architects and, finally, on the skill of the computer scientist. The archaeological information system (SIABRA) is also a precious and extremely important resource that is used for the virtual reconstruction.

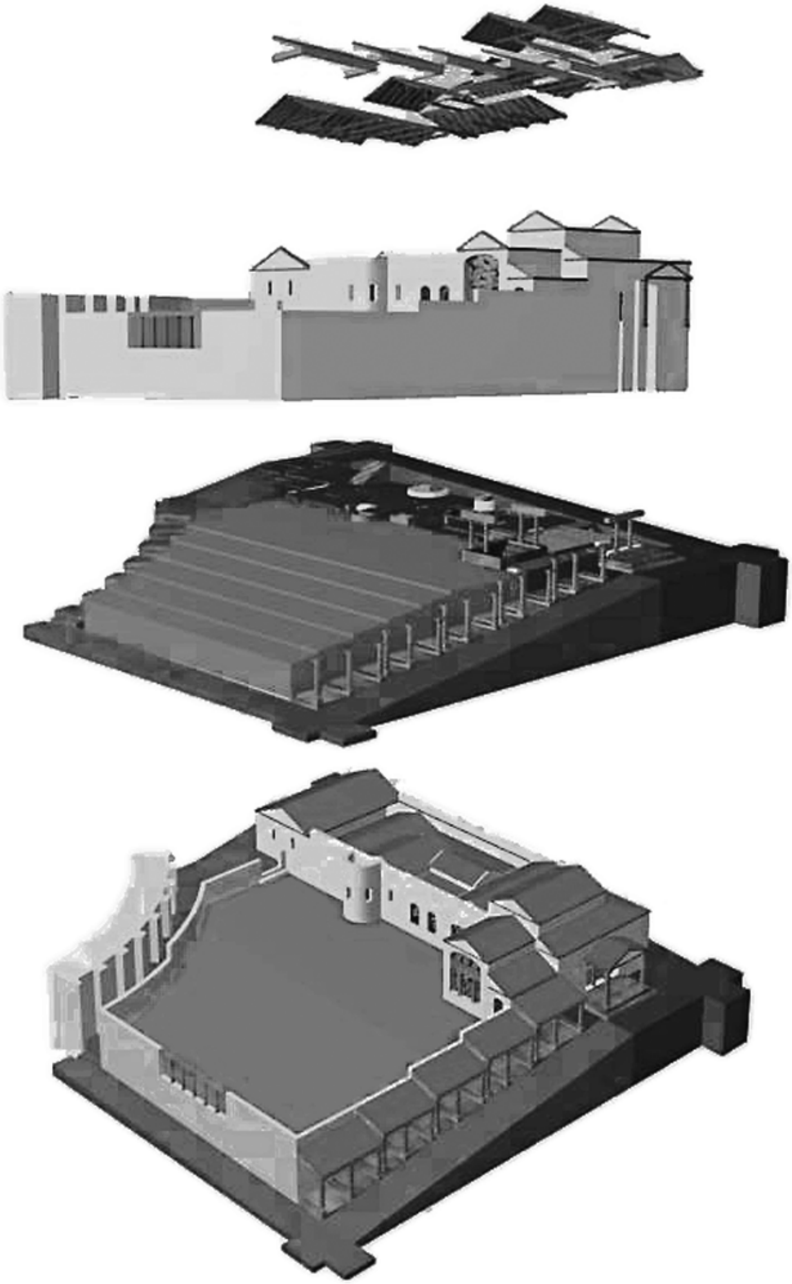

Fig. 1 – The Roman Baths of *Bracara Augusta*. Phase I, 2nd century AD.

The production of these models is based on the interpretation of the specialists and use a carefully calculated illumination model, where the material properties of the 3D-models are taken into consideration. These 3D-models can be seen in a pre-recorded animation or the user can make a walk-through using a VRML model.

5. Conclusion

The past is an increasingly important part of present representations. The generalisation of the idea of past heritage as an historical and cultural resource in the last three decades has originated an important pressure over the discipline obliged to produce, not only an academic discourse, but mainly a democratic vision of our past. The general methodological and technical evolution of archaeology as a discipline paid crescent attention to the necessity of obtaining crescent amounts of information to make possible the reconstruction of past societies. In this progress computer sciences became a helpful instrument of research used in all levels of the archaeological work and a powerful way of restitution and representation of collected data. Being impossible to think about the future of archaeology without computers it is important to be conscious both of the constraints of knowledge production of the past and also of the dangers of an oversimplification of data which could be considered necessary for a large dissemination of the past.

In reality the production of pictures and stories about past worlds is a sophisticated output of multidisciplinary knowledge that obtains credibility inside different scientific domains. In our opinion the recreation and the representation of a mediatised past demands high scientific performance and a crescent control over information without which recreations are no more than mythological fantasies.

A mediatised presentation of our archaeological heritage requires quantitative and qualitative information provided by a research sustained by scientific proceedings, a multidisciplinary work of reconstruction and high quality products, which depends on the development of techniques of representation. Nevertheless we must be conscious that our models of the past societies are nothing more than dated products resulting of our ability to deal with available data. In reality models of the past are not the past itself but new data generated by its conserved remains which are the only part of the past itself and the bridge that links us to it.

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ABSTRACT

The purpose of this paper is to present an archaeological information system and multimedia application used to record, manage and diffuse the data provided by the excavations conducted, since 1976, in Braga, Portugal, and related to the "Urban Rescue Project of *Bracara Augusta*".

The Geographical Information System built to manage and process the archaeological information (SIABRA), created by a team from the Archaeology Unit of Minho University, which was responsible for the Project, is presented. A natural result and advantage of this System is to simplify and enhance spatial analysis and data articulation related to the main buildings which have already been found, as well as the urban interpretation. One further advantage is the three dimensional model reconstruction, where a specialist (archaeologist, architect, urbanist) can analyse and visualise complex and diachronic information concerning the Roman town, in order to simplify the global understanding of buildings, their reconstruction phases and the general relationships between them.

The development of virtual environments reproducing archaeological sites, such as the Roman town of *Bracara Augusta*, can be considered as an important and powerful tool for facilitating the research of specialists and improving heritage consciousness.