

DESKTOP VIRTUAL REALITY SYSTEMS BETWEEN SITE AND LANDSCAPE

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ABSTRACT

Archaeological sites are often invisible: because they disappeared during the centuries or are hidden under the ground, far to be reached, most of the times. Sometimes these sites, even if slightly perceptible, are the only memory of the territory and the key of their history and evolution. Even the future of a land can sometimes be understood by the comprehension of its past history and through Desktop Virtual Reality Systems.

Keywords: 3D GIS, Archaeological landscape, Augmented reality, Desktop Virtual Reality, OpenGL, remote sensing, sites management.

1. INTRODUCTION

Landscape isn't a simple sum of its principal constitutive elements... There are cases where a combination, an aggregation is bigger than the sum of its parts and this is because the combination of the parts isn't a simple summation but it can have the characteristics of a product or even of a logical product creation¹.

Who needs Cultural Heritage? How can be managed still existing archaeological sites? And, on the other side, how can be accessed something that is no more visible or comprehensible? How can be recorded this memory? And, at last, how can be communicated, and shared with the world community, something that is intrinsically complex, decoding it without 'flatten' it? Which is the contribution of past Computer-Graphics applications? and what can last-generation Desktop Virtual Reality Systems do for the comprehension and the dissemination of Cultural Heritage knowledge?

This paper proposes a few questions and a few methodological answers, presenting, in the meanwhile, applications that represent possible solutions in two main fields. On one side, indeed, there is the 'Landscape-element', that comprehends the environment, its natural configuration, its geomorphologic structure, together with human settlements, and, on the other side, there is the 'Site-element', made by buildings and other artefacts. These two fields have different characteristics (in relation with the scale, for example, we can also speak of 'extra-site' and 'intra-site') and need different treatments, even in terms of digital solutions.

In the first case (Landscape) two projects, carried out by the research team, will be analysed:

- the reconstruction of the ancient landscape of Aksum (Ethiopia)² and
- the Roman landscape of Bologna (Italy): the ancient Bononia³.

In the second case (Site) other two important projects will be examined:

- the house of Vettii (Pompeii, Italy)⁴

² Aksum Project is carried out by CNR ITABC (Rome, Italy), Istituto Universitario Orientale (Naples, Italy), Boston University (Boston, USA) and CINECA (Bologna, Italy), in co-operation with Aracnet (Rome, Italy). The team of the Virtual Project comprehends: Maurizio Forte, Steven Kay, Eva Pietroni and Claudio Rufa.

³ Bologna Project's has been carried out by the University of Bologna (Department of Historical Disciplines, PhD in History and Computing whose coordinator is Prof.sa Francesca Bocchi), CNR ITABC, CINECA (Visit Lab), with the founding of Spinner Project (Regione Emilia Romagna). The VR team comprehends: Maria Elena Bonfigli (CINECA), Luigi Calori (CINECA), Maurizio Forte (CNR ITABC), Massimo Alessio Mauri (CINECA), Sofia Pescarin (CNR ITABC), with the co-operation of Dr. Jacopo Ortalli (Soprintendenza ai Beni Archeologici of Emilia Romagna) and Dr. Stefano Cremonini (Dep.of Geology, University of Bologna)

¹ BATESON G., *Nature and Mind*, 1979.

- the Scrovegni chapel with Giotto's Frescos (Padova, Italy)⁵

2. COMPUTER GRAPHICS AND VIRTUAL REALITY SYSTEM.

In this paper we will talk about Computer Graphics and Virtual Reality. A short explanation of these terms is perhaps needed. We are used to distinguish them, indeed, on the basis of *interactivity* concept: Computer Graphics isn't interactive such as Virtual Reality⁶.

In the past decade Archaeology has experienced a certain number of CG applications, such as 3D reconstructive models, animations, videos... But which is the contribution of these applications? We might say that this experience seems to have been almost unconstructive and failure, at least if we compare the number of "objects" or products created and their use, distribution and dissemination. At the beginning of computer applications⁷ we could talk of tens of 2D and 3D reconstructions; today it's almost impossible to estimate their number, even approximately.

This fact proposes a first issue that can be seen also as a problem of "communication" or, in other words, of what we would like to do and communicate and, then, how we want and can do it.

Utility and purposes.

Either we want to approach these topics keeping in mind their didactical purposes or their importance for the conservation of the historical memory of a territory, the **communication** of a digital product appears to be very significant and central. And even in the case of landscapes and sites dynamics studies is important to establish a mutual communication between researchers in order to **share** information.

But what lasts of the entire collections of videos realised, cds, archaeological and historical sites reconstructions that have been created in the computer of the scientific community, universities, research centres, etc. ? What has become really part of the worldwide community patrimony? Sometimes, occasionally, just a few snapshot in a publication or a video tape in some university laboratory.

Use

⁴ Vettii DVR system has been implemented by ARACNET (Eva Pietroni and Claudio Rufa), TREERRE (Angela Bizzarro, Stefano and Alessandro Tilia), CNR ITABC (Maurizio Forte) and ICR (Central Institute of Restoration)

⁵ The Scrovegni Chapel's 'Multimedia Centre' is directed by Padova City Council (Department of Cultural Affairs). It is produced by Archè srl, Bologna; Arcadia, Padova; CNR ITABC, Roma; Aracnet, Roma; NoReal, Torino; ICR (Central Institute of Restoration), Roma; with the founding of Wiegand Foundation, Nevada, USA. The Virtual Project is directed by Maurizio Forte (CNR ITABC).

⁶ For VR concept: see BARCELO J., FORTE M. and SANDERS D., 2000

⁷ See CAA proceedings

The concept of "use", in the sense of what can be done for communicate and share information and how information can be stressed, lays on another level. What **Virtual Heritage** can do about these issues? And moreover, what it can do about existing sites management (for non-existing sites, indeed, is not a matter of management)? Emerging technologies and last generation computers allow to do a lot of things for Cultural Heritage, but what we can observe is a lack of solutions that could really help their fruition, the fruition of something that is part of humanity ownership, patrimony of the different nations those vocation is also their preservation.

What can be proposed as possible solutions? If we accept the concept of 'cognitive increase', in a batesonian way, as a perception of a meta-information derived from the comparison between two pieces of information or conditions (difference), combined with temporal changes (time)⁸, we would probably agree that the problem of how to communicate and make perceptible and available cultural information, is connected with the creation of digital differences. In this sense differences of scale and time, together with the perception of the landscape and sites, through the movement inside them (interaction), all integrated in one environment, can stress concepts and information.

An example can be the transposition of GIS data in different systems of visualisation. New software solutions, in this case, could be found to work on modelling aspects of settled landscape and sites. These two directions have been followed by the équipe's projects: in the first case the landscape, as anthropological and natural space, is considered at a macro scale (Aksum – Ethiopia – project and Bologna – Italy – project); in the second, a micro scale has been treated, considered as architectural and cultural space (House of Vettii – Pompeii, Italy – and Scrovegni Chapel – Padova, Italy). These two fields of applications are different not only in comparison with the scale but also with data typology: in the first case GIS data or mixed data, in the second case the completed architectonic model, whose context is the architectonic model itself and its history is its own history, at least in the case of single monuments. The two categories of data can sometimes overlap, but essentially we can say that we're dealing with different information.

What kind of increase or insufficiency can be found in Virtual Reality applications?

Virtual Reality (VR) is a visual medium and this emphasises the need for an adequate system to re-create and construct archaeological landscape, based on interpretations. However, before choosing the means of communication, it is necessary to define the requirements of a VR system. In planning digital phases it's necessary to identify several themes in order to achieve to a successful completion of the project itself.

First of all it's necessary to define the level and the typologies of interactivity. Only **interactivity**, indeed, provide a sense of being absorbed, that is a fundamental aspect of cognitive landscapes study⁹. Other important characteristics, for the visual impact of the models, have to be identified, such as **solidity**, **mobility** and

⁸ BATESON G., 1979

⁹ FORTE, 2000

texture. Even **sound** is proved to be significant for the virtual world (sound of the nature: running water, wind, etc.). Strictly related with interactivity there is also the level of **freedom of movements** within the virtual space; the VR experience seems to be really relevant just if the user can choose its paths in the exploration. At last, another behaviour should be added to the environment, even if the result leads the user slightly far from what we can call real dimension: **queries.** The possibility of querying objects on the scene can give the user its own interpretation displaying meta-information on how the models were thought, which sources were used, for example, to get to different reconstruction phases. In order to visualise new layers of information on the scene, after a query, it is necessary to establish a connectivity between the VR system and an underlying Database. The final and most important requirement of a VR project is an **open structure**; this would allow to create continuous adjustments and updating. In fact one of the purpose of a digital project isn't the generation of a single and unique virtual model, but the **creation of a process of regular revisions.**

Virtual Reality offers the opportunity to move away from conventional graphic representations that are often simplified and abstract.

3. PROJECTS AND APPLICATIONS

3.1 Landscape

In the case of "Landscape-category" data must have a direct connection with a GIS project that has to lay underneath. The DVR (Desktop Virtual Reality) system realized for Aksum and Bologna projects was thought as to maintain the spatial context of data. After importing directly GIS data in the system, a range of different techniques have been assessed, including VRML and OpenGL technology.

3.1.1 Aksum (Ethiopia) Virtual Project

The Aksum Project involved the study of an ancient landscape where it is being attempted to reconstruct a landscape that existed in the 3rd and 2nd millennia BC. In order to fulfil the objectives laid down for the Aksum VR, a **3D terrain builder** was identified as the most suitable product with which to achieve the projects goals.

Behind the project there are years of data collected during a long phase (since 1993) carried out by the archaeological Expedition of Istituto Universitario Orientale (Naples - Italy) together with the Boston University (Boston - USA). The archaeological investigation on Bieta Giyorgis hill has allowed to clarify the different phases of Aksumite state development (late 1st millennium BC- early 1st millennium AD), to study the origins and urban development of Aksum within its environmental

setting¹⁰. Thanks to an interdisciplinary co-operation between archaeologists, paleoethnologists, archaeozoologists, ethnoarchaeologists, and geologists, a great amount of digital data have been acquired, which have been collated within a GIS. The project included even Remote Sensing applications through the analysis of 2D and in 3D digital data such as: aerial photos (1:60.000), satellite images (Landsat TM, SPOT XS), cartography, landscape documentation.

These data form the materials from which the VR model is built.



Figure 1. The different data used for Aksumite landscape reconstruction (Ethiopia): aerial photo and satellite images.

In January 2000, a program of scientific cooperation was established between ITABC and a U.S. company (Terrex) to use their software (TerraVista) for archaeological purposes. Terra Vista was specifically chosen even because it employs an OpenGL working environment and has a close connection with GIS software packages, such as Esri ArcView or ErMapper. Moreover the format exported in is an OpenGL flight file (FLT) that is a widely supported standard which can be easily used or imported in other software programs.

The stages of the project involved the application of advanced digital technologies for a detailed reconstruction of the archaeological landscape: analysis and classification by GIS and remote sensing, interpretation and communication through virtual reality and visual information systems. Three phases have been necessary to get to the final simulation: firstly the input of the sources into the 3D terrain database program Terra Vista, secondly the creation of the model and lastly the generation, including defining the parameters, of the landscape.

In summary, VR has offered the opportunity of revolutionizing the way to re-present the past, thanks to the sense of immersion that it offers, due to the quality and accuracy of the virtual world and the ability of the software chosen to offer an infinite number of interpretations.

In this way some important archaeological questions have been raised: how and what we can perceive of archaeological landscape? What are the relationships between the aerial photo-interpretation, satellite images and the landscape? How can the

¹⁰ Excavations at Bieta Giyorgis were aimed at testing the hypothesis, based on traditional Ethiopian sources, that the hill was an area of early development at Aksum

3D reconstruction help us to reconstruct and to interpret archaeological landscapes?



Figure 2. The actual landscape in Ethiopia and the virtual archaeological landscape reconstructed.

Therefore, the possibility of interacting in real time with the reconstructed landscape has produced new cognitive scenarios of visual anthropology either for the scientific communication and the collective knowledge. The result was also the creation of created a virtual and diachronic museum of the whole territory, on the basis of the visual cultural information and of the complexity of the eco-cognitive systems¹¹.

3.1.2 Virtual Bononia: a city under the city

Virtual Bononia is part of a PhD research project of the Department of Historical Discipline of the University of Bologna¹² and of a wider project, called Mindscape, carried out in co-operation with CINECA Supercomputing Center (Bologna) and with CNR ITABC (Rome)¹³.

Behind the project there is the concept of “*mindscape*” intended as to indicate something between the landscape and the visual and cultural perception of it¹⁴. Mindscape goals are to study and to build a tool to **manage and interact**, naturally, with cultural information and to achieve a system not intended only to **display** generically visual information, but to create a virtual and real time environment in order to **work with** historical, archaeological and geological issues. The system, in this way, has been used even during the different phases of a research, as well as after the end of the research, to communicate its results and to disseminate dynamically hypothetical reconstructions.

¹¹ See Proceedings of Boston conference, in press.

¹² PhD in ‘History and Computing’ whose coordinator is Prof. Francesca Bocchi.

¹³ With the founding of a regional (Emilia Romagna region) Italian Project called Spinner.

¹⁴ See FORTE, 2002, p.119-122



Figure 3. The actual digital landscape of Bologna (Italy) on the left (I LEVEL) and the virtual roman landscape reconstructed on the right (II LEVEL).

The case of Bologna seems to be quite meaningful. The city indeed has a strong Medieval tradition that can be clearly perceived, even today, having a look to the aerial photography or just walking among its streets: the shape of the city has maintained this mark in the organisation of space. There isn't the possibility, on the other side, to have any idea of its aspect before VII/Vth century A.D., during Roman Times for instance. Archaeological excavations, since the end of XIX Century revealed that there is something like ‘a city under the city’. Many remains have been investigated in different part of Bologna. These remains are invisible for common visitors and, moreover, are widespread and, often, just slightly significant, even because of the difficulty of undertaking complete excavations in a deeply urbanized area. What it usually happens is to obtain few information mainly during public works¹⁵.

For all these reason a tool has been studied in order to help the comprehension of the landscape (how was its aspect at Roman Times? Which is the connection with the present city? What is there under a street or a square?), useful even for the municipality to manage archaeological remains in its urbanistic planning (risk map).

A GIS project has been realised. In the GIS geographical, geological, cartographic and archaeological data have been collected and connected together and to an external ODBC database. In this database all information retrieved in Soprintendenza archives have been inserted about archaeological excavations conducted since the end of ‘800. For each Roman site and remain recognized, the information of depth (below the street level) was taken and used to build a **Digital Terrain Model (DTM) of Roman Age**¹⁶ (II LEVEL). This spatial model was used in comparison with Actual Digital Elevation Model (I LEVEL), particularly useful even to do some spatial analysis which could eventually give indication on hypothetical landscape reconstruction.

On the basis of GIS project and of analysis made, a **DVR system** was realised with all geo-referenced data. Two navigation levels have been studied (Fig. 3). The fist (I LEVEL) represents the **actual landscape** with DTM, aerial photographs, landscape elements, such as rivers, streets, railroads... A layer of

¹⁵ See PESCARIN, 2001, pp. 125-126.

¹⁶ See PESCARIN, 2001, p. 125

archaeological site was added, represented by simple 3d flags. The second level (II LEVEL) regards the reconstruction of **Roman landscape**. For this reason roman DTM was used, together with archaeological layers and geographical hypothetical data (river, cultivations ...).

With *DVR-Bononia* we intended to propose a possible indication of urban spatial organisation, rather than to obtain a realistic reconstruction, quite difficult in comparison with the information available. For this reason 3d models were put in the scene: generic models of attested and validated monuments.

Furthermore we tested the possibility of getting a real cognitive increase in the comprehension of the territory by an operation of **interactive comparison between two landscapes**: the actual and the Roman ones.



Figure 4. A frame captured during the navigation on the landscape of Roman Bologna.

3.2 Sites

3.2.1 House of Vettii (Pompeii – Italy)

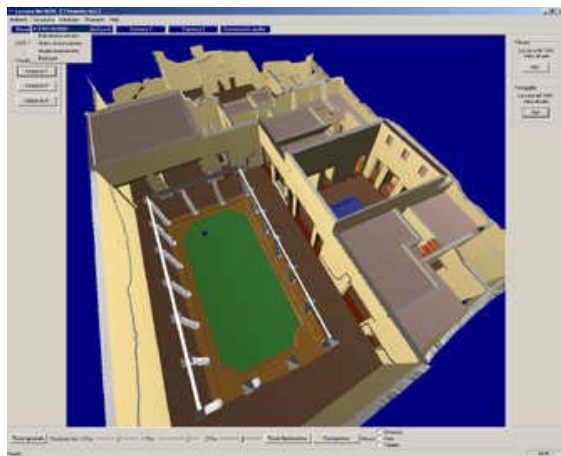


Figure 5. House of Vettii, Pompeii (Italy). 3D Model of the house

In the case of the House of Vettii, Pompeii (Italy) a virtual project has been studied in co-operation with the ICR and CNR in order to get to a **visual interaction** with the monument and in particular to provide an immersive three-dimensional system to query conservation and restoration data.

In order to build the 3D model of the house, 3D and photographic data were acquired through a total station and a laser 3D scanner (Minolta e Cyrax). The orto-photo-mosaic realised was used to create the different textures for the geometrical model.

Inside the model of the entire house (150.000 polygons), a room was modelled at an elevated level of detail (75.000 polygons).

At the same time, contents, context and interface were studied in an OpenGL programming environment. Through the main interface (Fig. 6) different data (vectorial layers, video, photos, texts) are accessible; they can also be combined following various hierarchic and thematic levels.

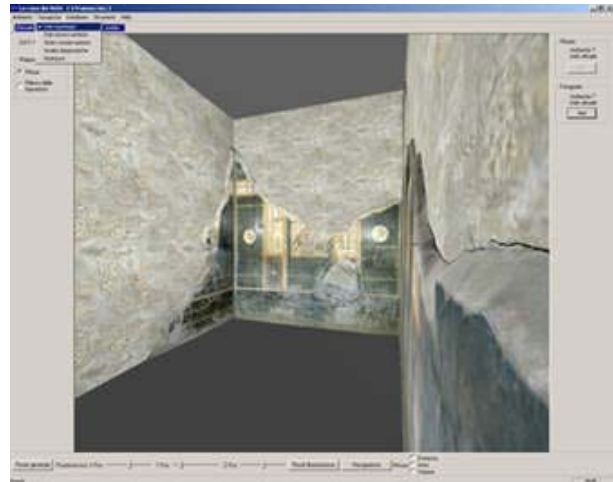


Figure 6. House of Vettii, Pompeii (Italy). The DVRa System

The user can select between different 3d thematic contexts in order to use the most useful one for his own interpretation or his studies. It's possible to select and visualized just a few architectonic typologies, deconstructing the model and immediately constructing it, in order to amplify the cognitive potential. Through tools (such as a rule) it is possible to increment this potential further on, measuring, for instance, the area or the volume of a particular zone of the walls.

Most of thematic examinations can be accessed by changing, in real time, the mappings of the model or visualizing vectorial data as layer applied directly on the surfaces (frescos)

Even other categories of multimedia data can be added (movie, pictures, archivistic reports, texts...) and visualized in different windows that appear on the OpenGL application, without stopping it: this allows the user continually to create relations between explanations, themes and spatial environment.

At last, it's extremely important to have the possibility to build a connection with the Database for a mutual exchange (i.e. the possibility of visualizing the result of a query as a layer over the 3d model) that can be really significant.

What was obtained is a complex informative three dimensional system, whose data are integrated and accessible in a **multidisciplinary** way.

3.2.1 Scrovegni Chapel (Padova – Italy): DVR installation.

The application of technologies developed by the CNR for the research project DVR Archaeology, in the case of Scrovegni Chapel has produced a **Virtual Reality system** for the Municipality of Padova, with the creation of a 3D application of high graphic resolution that provides multimedia information and related documentation. This application will be hosted in an underground room (10x20 m) near the City Museum. The room will be fitted with 7 installations that will help the visitors to study and understand the Chapel, Giotto's frescos and his artistic and historical context. The purpose of the room is to prepare the visitors before they enter the real Chapel itself. Since March 2002, indeed, after a long phase of restoration of the monument, each visit of the Scrovegni Chapel won't last more than 15 minutes (for a group of 15 persons). The virtual project was thought just on the basis of this difficult and short fruition.



Figure 7. Scrovegni Chapel, Padova (Italy).
A moment of the navigation in DVR application.

The application realized (that we also call “cognitive box”), thanks to the 3D interactive level, greatly enhances perceptive and cognitive properties of learning, providing visitors with an advanced system of information gathering data interaction and communication (through an extremely friendly interface)¹⁷. At the end of the visit the visitor can come back and explore again the virtual model, according to a process of informative *anakyclosis* (cognitive circle: virtual-real-virtual-real again): in this way the cultural information is acquired for redundancy and spatial contextualization. The *anakyclosis* is concluded when a mental information is identified (already seen) and the user can elaborate it.

In conclusion starting from informative geometry redundancy, dealing with a same topic, a permanent cognitive *flexus* can be created, increasing learning and memorizing faculties.

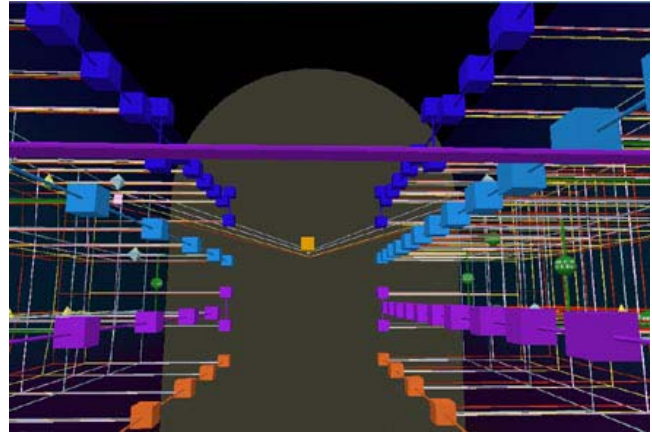


Figure 8. Scrovegni Chapel, Padova (Italy). A moment of the navigation in the DVR application: the cybermap.

3.3 Conclusions

The last question could be: what can we do with *digital* Cultural Heritage patrimony? Perhaps a solution is to think in terms of “sharing knowledge” and of community, or cyber-community, that could access non visible data (or data accessible in other ways).

The entire effort seems to be justified today even by the portability of these systems that can be programmed not only for graphical workstations, but also for PCs with last generation 3D graphic cards (OpenGL compliant). We are moving quite rapidly from Graphical Workstation (expensive) to common Personal Computer (affordable): this could be seen as the starting point toward a real diffusion of cultural topics and applications, towards a *domestic use* of them. In a short time there will probably be the possibility of watching these applications (DVR), navigating in virtual environments, directly in our houses, experiencing an ‘*augmented use*’ and, in the meanwhile, a ‘*short fruition*’ of Cultural Heritage.

New devices will be soon available at an affordable cost, answering the increasing request of having more immersive systems, capable of shorting the distance between the user and the virtual world¹⁸ and creating a collective experience.

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¹⁷ <http://www.arche-srl.it/2303>

¹⁸ There is already a trend about replacing standard monitor with stereo projector.

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Araonet multimedia studio, founded by **Eva Pietroni** and **Claudio Rufa**, started its activity in 1998, in Rome. It is specialised in planning and realising multimedia products, virtual reality applications, DVD Video, Web sites, musical compositions. The activity is oriented toward the study, documentation and communication of Cultural Heritage, using modern, interactive technologies, with particular attention to museums (real and virtual). Araonet collaborates with National Council of Research (Institute of Sciences and Technologies of Cognition and Institute of Technologies applied to Cultural Heritage), with Italian Soprintendenza (to Archaeological and Historic-Artistic Heritage), with Municipalities and Universities. The operators are experts in communication, history of art, archaeology, architecture, but there are also programmers, art-directors, designers, photographers, artists, musical composers. They may be contacted at: evapie@tin.it; clarufa@tin.it

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