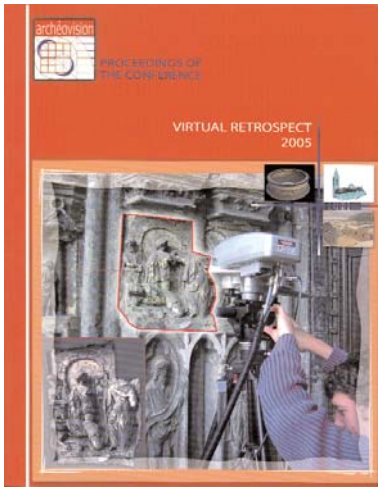
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THE VIRTUAL RECONSTRUCTION OF ARCHAEOLOGICAL LANDSCAPE: FROM THE FIELDWORK TO THE COMMUNICATION THROUGH REAL TIME APPLICATIONS. THE DIGITAL NARRATIVE MUSEUM OF THE APPIA ANTICA PARK

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Abstract : In this paper we will answer methodological and technological problems of the virtual reconstruction using OpenGl software in order to project, reconstruct and explore the archaeological landscape in real time. The "Appia antica" project is an extraordinary case study able to integrate different spatial technologies: remote sensing, laser scanning, mono and stereo photogrammetry, photomodelling, DGPS RTK (real time kinematic), GIS. Technologies used are turned towards two research directions : the first one is the topographic and architectural documentation of monuments for GIS and spatial archives, the second one is the creation of a virtual reality system dedicated to the narrative museum of the Appia antica. Scientific, geographical, antropological, cultural, narrative aspects are all together costitutive elements of the hystory of the archaeological landscape, they belong to its memory.
How did ancient people lived in the territory? What kind of activities did they develop? Which symbolic values did they attribute to the places? What kind of relationship did they establish with the territory and in consequence among themselves? These are the main questions a project of communication should face.
It is very important to preserve the link between the fieldwork and relief activities and virtual reality communication. For this reason our efforts have been oriented to experiment and find a common protocol to manage data, without loosing information during the successive phases of elaboration and communication.

Keywords : augmented archaeology — integrated technologies — GIS — narrative metaphors — multidisciplinary approach.

1 Appia Antica Project

In the Appia Antica case study, we worked developing a complex four-years project. It was a good chance to experiment different technologies and approaches, allowing a continuous comparison with different mapping and VR techniques. The project also gave the possibility to follow the entire process of data production: from the fieldwork to virtual reality.
The Appia Antica project (the archaeological park of Roman Via Appia, located in Rome, Italy) started in 2002 and it's still under development, since it will be concluded in 2006. It is developed by the interdisciplinary team of CNR ITABC, together with Rome Municipa Archaeological Superintendence. The work is characterized by an intense activity of archaeological and architectonic survey (topographical and architectonic mapping and "micro-topographical" and "micro-architectonic" mapping) with the goal of acquiring data for a real-time spatial interactive system. All the techniques used (DGPS, Total Laser Station, 3D Scanner Laser, 3D Stereo Photogrammetry, Photo-Modelling Techniques) are used in integration.
All the data acquired is post-processed: part of them (topographic information) are overlaid in a GIS project, while 3d models (architectonic information), obtained from scanner-laser and photo-modelling or reconstructed from archaeological sources, are geo-located and connected with external multimedia databases. Even territorial 3D information is processed in order to be used inside a Desktop Virtual Reality environment, based on Virtools for the off- line museum application (www.virtools.org) and on OpenSceneGraph-Virtual Terrain for the on-line version.

1.1VR WebGIS

For the on-line VR application we based our work on Open-SceneGraph and VTerrain libraries (www.appia.itabc.cnr.it). The project, through the Appia Antica case study, confirmed that the use of integrated technologies and the combination of different typological data
is extremely useful in order to manage archaeological and historical information inside GIS and Virtual Reality Systems, in a three dimensional, interactive and flexible way.

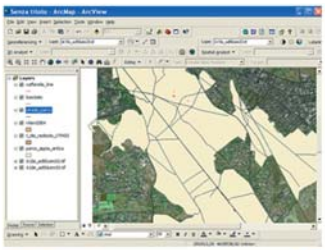


Fig. 1a: Example of GIS project (using ESRI ArcGis).

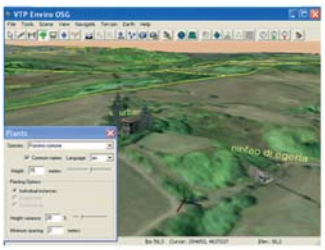


Fig. 1b: Example of landscape modification in VT Enviro.



Fig. 2: Web navigation inside the archaeological landscape of Appia Park.

At the same time, this approach allows '"scaled" versions, useful even for cultural content dissemination, at different levels, without loosing any scientific precision.

2 The archaeological landscape as a digital ecosystems

The integration of different technologies can greatly increase the level of knowledge of the archaeological landscape in terms of information, interaction, learning. According to our approach, technologies are oriented towards two directions:

1) acquisition of data on site, topographic survey of the territory and spatial documentation of archaeological structures;

2) creation of complex virtual reality systems to let the public explore and interact with cultural contents. As we'll explain below, we would define these systems as "virtual ecosystem". When we move, interact and have experiences in the surrounding world, we learn by observing the different results and consequences that our actions produce. Our mind interacts with the world through multiple associations of ideas and it organizes information in a reticular way, so also a virtual informative system should be structured and accessible according to reticular metaphors, complex interaction and connected behaviours.

"Without context there is no communication" is one of the basic principles of the Bateson's cybernetics; one needs to contextualize information for interpreting all the relations and processes of an environment (real or virtual). Receiving and processing information means to continually acquire new differences, the more we create difference between ourselves and the ecosystem, the more we learn.

The priority of the archeological information consists in the contextualization of data and of cultural itineraries, in the inter-relation between human life and sites, landscape and archaeological objects, the life of the past and the life of the present.

The more the information enhances difference and connectivity the more the symbolic associations grow and the possibility for visitors to assimilate and elaborate cultural contents increases. In this sense a network of relations among objects, sites, characters, narrative themes, has to be established to increase the communicative potentialities of the informative system.

The three-dimensional virtual envirnoment is the result of scientific elaboration of geographical and topographical data. These types of data represent a very important and usefull base of documentation, especially to consitute digital archives and to apply correct strategies of conservation to the territory. But they cannot be sufficient to communicate to the public cultural contents, related to the intrinsic identity of places.

Scientific, geographical, anthropological, cultural, narrative aspects are all constitutive elements of the history of the archaeological landscape, they belong to its memory.

We need to introduce life to the environment, activities, characters, behaviours, narrative contents to allow the comprehension of the mind of ancient people, in relation with cultural models of the past and of present.

How did ancient people live in the territory? What kind of activities did they develop? Which symbolic values did they attribute to the places?

What kind of cultural message did ancient people perceive from the object? What kind of message did the author or the exibitor of the object want to transmit?

Which relations can we establish between past and the present culture?

3 Integration of data and levels of visualization

The Appia Antica project demonstrates that a VR system represents the unique possibility to correlate different ontologies, to link different types of data in an inclusive space. For our activity it is very important to preserve the link between the fieldwork and relief activities and virtual reality communication. For this reason our efforts have been oriented to experiment and find a common protocol to manage data, without loosing information during the successive phases of elaboration and communication. This is the sequence of software used: Arcview-ArcGIS, Terravista (GIS elaboration), Photomodeler (photomodelling), Cyclone and RapidForm (elaboration of data acquired by laser scanner), 3D Studio Max, Photoshop (optimization and design of the landscape), Virtools-DEV (graphic real time engine).

It is remarkable to underline that all the data are completely compatible in format and geometry.

The VR application, The narrative museum of the archaeological park of Appia antica, tries to integrate cultural content, visualization, tools of analyses, interaction and

narrative metaphors to communicate the memory of the landscape, from the ancient times until now. In fact we retain that the archaeological landscape is not to be considered as the ancient landscape only, but as the landscape as it has been modified by time, the human activities and culture through the centuries, from the classical age to our times. Only the consideration of this continuity and the comparison of different ontologies can help us to make a hypothesis, interpret relations and understand cultural contents.
If we collect all the data in a 3D interactive environment we'll find that one unique vision is not sufficient to allow an integrated and structured comprehension of the contents. In fact data have been acquired and represented in different scales and levels of detail, and they have to be organized according a multidisciplinary approach and specific metaphors of communication and interaction. Each level of representation is functional to the kind of information we want to communicate. Reconstructive research in the field of virtual archaeology uses, in interpretative processes, *top-down* and *bottom-up* rules, integrating multiple methodologies.
The *bottom-up* approach starts from modelling data captured in the field, in order to create, finally, a virtual "anastylosis" of the archaeological structures.
On the other side, top-down rules use the mental faculty of making reference patterns, to proceed through comparative associations referred to specific typologies (we could call mental maps) for interpreting and reconstructing fragmented and uncompleted ruins.
In making a VR system, one has to include top-down and bottom-up rules, giving the user the possibility to integrate both approaches in a transparent way.

4 Virtual story telling: The narrative museum of the archaeological park of Appia Antica

In the following section we'll try to describe our virtual reality system *The narrative museum of the archaeological park of Appia Antica*. The aim of this project has been to utilize all GIS, topographical, architectonic data to construct digital spatial models, and associate them to a communicative system intended for public and educational use.
A trip through the 3D model of the territory of Rome, an overview that employs Landsat ETM maps (resolution 30 mt), helps us to contextualize the Appia Park before analysing and observing in detail the environment (fig. 3).
The area of the park is highligted and getting closer in, entering in the next level of detail, it is possible to explore in real time the holistic reconstruction of the archaeological landscape, described by a more resoluted digital model mapped with Ikonos images (resolution 1mt, fig. 4).
Some tools allow us to modify the visualization, changing the textures of the geometry and loading cartographic layers or highlighted boundaries of the areas of interest.
It is also possible to measure distances on the territory, or to open a superimposed, smaller top-view, a kind of navigator that helps us to orientate our movements in the landscape.
It is possible to choose two areas of interest, the Caffarella



Fig. 3: Flying over Rome, VR application.



Fig. 4: the exploration of the Caffarella valley and interaction with animated characters, VR application.

valley and the Appia Antica Road, and explore them in a successive, more detailed level of holistic representation. At this level not only the territory but also structures, buildings, ruins and the larger vegetation are described in 3D.
Flying over the Caffarella valley other tools have been added to the previous ones, to improve and magnify visualization, such as a telescope that allows us to look with more detail to the archaeological structures .
At this level we found general information about the valley, we can query the monuments and have access to the corresponding scientific and historical contents.
When we choose to walk inside the park we are fully immersed in the context, every element of the landscape is described in
3D and if we want we can decide to interact directly with historical and cultural contents through complex behaviours, narrative metaphors, characters and avatars.
While walking through the park we can meet ancient travellers, famous characters of the past, animals, talking sacred trees, gods that tell us tales about the park, legends, myths, stories (fig. 5-6). The user, exploring the landscape, will interact with cultural contents and will access metadata according to different behaviours and dynamic actions.
When we get near the archaeological structures we can listen to an audio explanation of the monument we are looking at,



Fig. 5: Talking tree in the sacred wood of Caffarella valley.



Fig. 6: God Almone in Nimphaeum of Egeria, VR application.

we can open movies, tales, animations, iconography, and so on; all the metadata are associated inside the three-dimensional space.
Sound is spatialized in the 3D space, so to communicate the specificity of different places also through the suggestions produced by sounds, noises, voices.
In the real time visualization and exploration of the whole landscape a simplified version of the object and monuments, obtained by photomodelling techniques, are used, while the high resolution version obtained by laser scanner are employed for a monographic analysis of the monument.
In fact from the 3D menu near each monument we can also access the successive level of detail, its monographic representation (models elaborated from scanner laser data, fig7-8), where the topological information can be analyzed in in more detail and other specific themes can be associated.

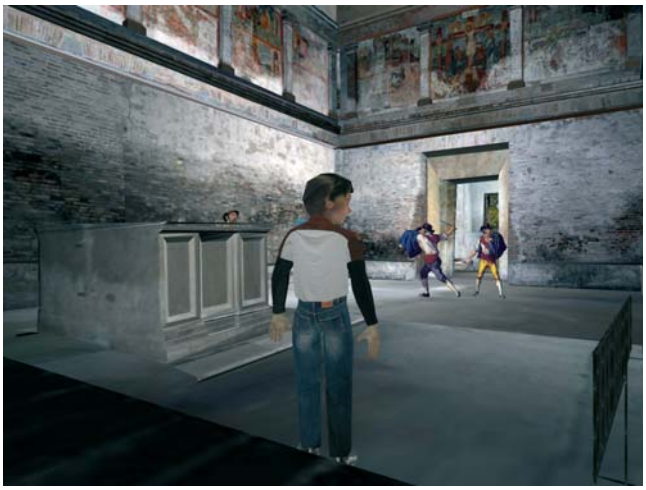


Fig. 7: Monographic view of S. Urbano Church, VR application.



Fig. 8: Monographic view of Nimphaeum of Egeria acquired by scanner laser, VR application.

For some structures, such as the Nimphaeum of Egeria and S. Urbano Church, we have the possibility to explore and compare the models of the monuments as they appear today with their hypothetical original aspect (fig. 8).
The axes of Appia Antica has been reconstructed from the fourth miles to Casal Rotondo, monuments have been acquired by laser scanner or photomodelling techniques (fig. 9), but the topographic survey and architectonic relief is to be completed during the next two years of work on the field.
A large part of the archaeological structures along the Appia Antica axes has been restored, reassembled, recomposed by Luigi Canina (1795-1856), a piedmontese architect exponent of the neoclassic and antiquarian culture. During his long studies he made a lot of prints, designs of archaeological views, prospects for building, detail of decorations. In these views the archaeological site, funerary monuments are represented as they were in the 19th century but also as Canina imagined they could appear in ancient times, in others he attempted a sort of virtual reconstruction ante litteram.



Fig. 9: Appia axes, topographical reconstruction, VR application.



Fig. 10: Appia axes, 3D navigation inside Luigi Canina's view, VR application.

We have chosen one of his reconstructions (a stretch between the fourth and the fifth miles of the street) and we have represented the view in three-dimensions, so we can make our avatar walk or run inside Canina's print, exploring and visiting monuments as he imagined them (fig. 10).

The narrative museum of the archaeological park of Appia Antica was shown to the public during the international exhibition of virtual archaeology, "Immaginare Roma Antica" at Traianus Market Museum in Rome, (September, 15-November, 15, 2005). The public had the possibility to explore and interact directly with the virtual landscape and cultural contents wearing stereoscopic glasses to enhance the impression of immersion inside the three-dimensional environment.

In the near future development of the Appia Antica project, we are also planning the creation of a special documentation center, hosting virtual reality systems intended both for scientific research and for public use.

5 Future development: artificial societies living in the archaeological landascape

According to echological thought, relations existing between the organisms and the environment dominate the whole knowledge of both the real and the virtual domain, and they have a foundamental rule in biological research.

In this field virtual reality can offer new advanced scenarios towards the development of new alphabets, new relations, new kinds of communication, interaction and learning.

Almost in all virtual real time reconstructions, landscape appears quite desolate, even if designers have taken a lot of care over the graphic reconstruction; we are accustomed to interact with characters and animals that move and act following pre-determined animations. So when a user returns a number of times inside the virtual world to explore it, the way to interact and to change information is quite similar and there can be no further surprise.

For this reason in the near future we would like to develop new technologies and a methodological approach to introduce autonomous agents inside the virtual archaeological landscape.

A living creature is characterized by the capability to auto-reproduce and self organize.

Artificial societies and autonomous agents perform behaviours established by themselves in relation to a specific situation produced in the virtual world or on the basis of casual effects; in the most advanced applications, agents are able to learn by interacting with each other or with the humans. In every case they influence each other according to different and variable dynamics and they interact with users generating a succession of unexpected events and actions. Moreover each agent can have a specific identity, described by some attributes and properties, these attributes allow it to develop special behaviours connected with its identity. When different identities meet and interact, different kinds of aptitudes, capabilities, inclinations, properties may be combined so creating a great amount of unexpected reactions. If we also introduce the possibility for the agents to learn new behaviours and information, as we said before, we can understand how much the complexity of the system can grow. Autonomous agents can populate sites, buildings, ruins, streets, marketplaces, meadows, ponds, they can be characters or animals, and according to their identity, they can be attracted towards particular areas of the territory and self organize.

A human user is considered just like an agent and could take part in social relations and interact with animals. The same function of the avatar could be interpreted as the possibility, for the user, to enter a virtual agent and to control it, totally or partially. The user could also migrate from one avatar to another, assuming different identities, so to establish different relations and behaviours between him and the environment.
In this way visitors should modify the virtual environment through their interaction, just as if they were interacting with a live creature in a real context. They should change the dynamic of movements and the actions that characters, animals perform in the space, they can move objects, they can leave traces of their passage and presence in the virtual environment.
This approach can be very useful to simulate and describe ancient and present life in the places; social, echological aspects of the context in which archaeological structures are immersed in time could be understood through direct experience. Moreover the power of attraction on the public could be surprising.
Science, technology and art are foundamental instruments to know ourselves, to understand, to communicate, for us to relate to the external environment, to learn through dynamic processes instead of static definitions. Even in the virtual reality domain these disciplines should be directly integrated.
This perspective supposes some foundamental questions, about the possibilities to create common alphabets and common metaphors of interaction :
What are the metaphors to relate human users, artificial societies and cultural contents?
Which codes can we share? Which signs? How can we create and share meanings? How can we elaborate these kinds of information?

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