

VR cooperative environments for the interpretation and reconstruction of the archaeological landscape

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Abstract

The Internet 2.0 has diffused a new approach enhancing creativity, multimedia communication, information sharing, cooperation: millions of people in the world are expressing the will to interconnect, co-create digital contents and share experience in the cyberspace. The possibility to develop complex dynamics of interaction inside the virtual domain are determining new scenarios in the field of cultural transmission. In this paper two case studies will be presented: the "Integrated Technologies of robotics and virtual environment in archaeology" project (supported by the Italian Ministry of Research), and the "Virtual Rome" project, two virtual collaborative environments in the web for the interpretation, reconstruction and 3D exploration of archaeological contexts.

Key words: CULTURAL HERITAGE, VR COLLABORATIVE ENVIRONMENTS, LEARNING, CO-INTERPRETATION.

1. Interpretation in archaeology

How do we develop our interpretations of archaeological landscape? How interpretation process can be enhanced? Which tools can be used for this purpose? How vision is integrated in this process and which are the risks that should be taken into account?

Interpretation has a central role in the cognitive process, because it creates a *link*, a bridge between vision and knowledge and also among archaeological observations or sources and knowledge. Landscape reconstruction final output is a visual result: it is a visual activity. From a neurological point of view, we observe in order to obtain a knowledge of the world. Our vision system is designed to get to this result as much as possible through three moments: *selection*, *exclusion* and *comparison* (ZEKI, 1999: 4-23). While we observe, in fact, we already make a choice, selecting constant aspects, referred to the shape, the colour and also the *relation* among objects, situations or concepts. We work to produce an ambiguous visualisation. Ambiguity is a positive value, since it regards the definition of general characteristics, proposing many different visions, in a single representation. Therefore visualisation does not limit the interpretation, when it translates many different situations into images. Contrariwise, it opens up to a more durable interpretation of the reality. When we deal with landscape reconstruction, we know that we face a complex topic: it is continuously changing, uncertain and made of so many different interconnected aspects, which need so many different disciplines (archaeology, paleo-ecology, physics, geology, etc.). We usually analyse the landscape through a twofold process of de-composition and re-composition. Therefore, the development of a cooperative platform, visual and interactive, could help to better interpret available data and to reach to more reliable and significant results. Keywords of such a platform are: communication, visualisation, spatiality, interactivity and sharing.

A visual cooperative system can represent a n environment where different fields can work together, sharing information, as

long as it is based on spatiality, three-dimensionality, interactivity and updating potentiality. The connection with digital archives and repositories is another requirements. *On line* access would allow a more efficient cooperation among distant researchers and will contribute to maintain continuously updated the system.

2. Perspectives of Embodied Web communities for cultural heritage communication and interpretation.

In the last years networked virtual reality and virtual communities represent a rapidly growing area of research and development. (FORTE, PIETRONI, DELL'UNTO, 2008). If the traditional chatting communities were growing in an abstract dimension without any sensorial engagement, the new embodied communities, live in a 3D context where the immersivity and the sense of presence depends on the possibility to see, hear, touch and act inside the virtual environment, moving the body in the 3D space, living inside the ecosystem in a continuous relationship of mutual perception, modification and adaptation (MATURANA H., VARELA F., 1980). Information exchange, cultural transmission, learning develop through processes that are not linear but reticular and always evolving, so the emerging behaviour of the whole system is the result of crossing experiences in the same 3D virtual domain. Despite the growing diffusion of new metaphors of "virtual aggregation" we have still a very limited understanding of how these virtual spaces impact on user interactions, cognitive processes and learning.

Virtual reality environments should integrate activities for the visitors, levels of visualization, models, explanations, metadata, storytelling, behaviours, tools of visualization and interaction, in order to "reconstruct" and communicate an ecosystem where all the information is integrated (FORTE et alii, 2008). Probably it is also necessary to guide users in their process of exploration and interpretation giving them progressive objectives and stimulus in order to make them not disoriented in a such

complex world: virtual storytelling and gaming rules can be very powerful instruments in this sense. In the field of cultural heritage the state of the art is still quite pioneering, because there are no Multi-user domains (MuD) specifically for sharing and exchanging cultural and scientific contents. Digital technologies and virtual reality are radically transforming the condition of perception and fruition of cultural heritage: artefacts and cultural sites are considered no longer as material, unchangeable and self-referent objects but as processes of relations, multidimensional entities in continuous transformations, co-evolving with the public and the environment. The digital representation becomes an “attractor” catalysing creative processes and behaviours, a domain where users cooperate in the definition of multiple stratifications of meanings (CAPPUCCI, 1993). Users construct their perception, identity, knowledge and communication through the interaction in the environment, exploring the space, speaking with characters and avatars, opening contents spatialized in 3D, modifying models and relations, sharing information and objectives with other users (SCHROEDER, 1997).

How can this continuously evolving universe of information really construct communication and knowledge? Which is the added value of embodied virtual communities in cognitive processes in the field of cultural heritage? How can they change the paradigms of cultural interpretation and transmission? How do users interact with each other inside virtual worlds? (SCHROEDER R. 1997). Which are the reasons for which users should prefer to move and interact in a virtual environment with other users rather than alone? Is the simple presence of other users sufficient to stimulate us in the exploration of the cyberspace or we need more motivations? How can they share and exchange data? How can we “guide” them throughout these complex ecosystems, stimulating his curiosity, interests and faculty of interpretation? Cyber games designers need to find very precise solutions to these questions, orienting users towards always evolving goals.

A very interesting project, developed by the Indiana University, is Quest Atlantis, an online virtual environment to engage children (9 -14 years old) in educational tasks. The purpose of this study is to understand how children and adults like the environment, which kinds of experiences and metaphors of interaction, with digital contents they prefer and which is the most efficacious approach supporting academic learning. Children, guided by a teacher, have to solve some missions, games, educational challenges called “Quest”. Completing Quests requires that they perform socially and academically meaningful activities such as conducting environmental studies, researching other cultures, make calculations, analyzing newspaper articles, interviewing community members and developing action plans. Quest Atlantis has been developing from 6 years and it is based on Active world platform (<http://atlantis.crlt.indiana.edu/>).

Researches in the field of embodied web community for communication and learning in cyber-archaeology domain (JONES, 2003) are developed also by the University of California, Merced, using Second Life platform. In collaboration with us they have reconstructed Livia's Villa (the suburban Roman villa of the wife of Emperor Augustus, I century B.C. - I A.C, placed near Rome) and within this space they organize lessons for undergraduated and PhD students of the University, studying which are the best interfaces, media, and dynamics of interaction in order to obtain an efficacious cultural impact.

Many people enjoy sharing the experience with other users, in order to exchange opinions, share feelings, help with the navigation, help with understanding the contents, and also socialize (GEROSA, 2006). They feel than sharing make the virtual experience more real, more natural, more material, and easier to remember. However some users think that sharing is conceivable only in an entertaining environment, hence not useful or negative in a learning context. (BONINI, ANNUNZIATO, PIERUCCI, PIETRONI, 2008).

In the following sections we are going to discuss about two projects developed by CNR ITABC for the creation of virtual reality and multiuser domains in archaeology. The cyber space of the FIRB project is a sophisticated collaborative environment of simulation for academic studies dedicated to archaeological multilevel contexts. The Virtual Rome project has developed a VR webGIS application for the interpretation, reconstruction and 3d exploration of archaeological and potential past landscapes of Rome.

3 The Integrated Technologies of robotics and virtual environment in archaeology project.

One of the key problems in archaeology is the difficult to manage huge amount of spatial data that are usually disseminated in various archives, different for formats, ontologies and typologies. The process of interpretation and communication becomes compromised by the inaccessibility of all data inside the same informative system. Moreover the scientific communities do not consider VR environment an operative tool for archaeological research: in most cases virtual reality applications are developed as final processing and 3D output of a previous long term work of research and study. It is not common to share information and interpretations, edit, simulate and test possible hypotheses in the same virtual domain.

A FIRB (Funds for the Investments of Basic Research) project, *Integrated Technologies of robotics and virtual environment in archaeology*, financed by the Italian Ministry of the University and Scientific Research, gives us the opportunity to experiment and realize a multi-user domain on the web addressed to a multidisciplinary scientific community.

(www.vrlab.itabc.cnr.it/FIRB/Release/Home.html)

The project, in collaboration with the Department of Archaeology of the University of Pisa and with Scuola S. Anna of Pisa, focuses on three archaeological sites: the Teban tomb 14 in the necropolis of Gurna-Luxor, the Temple A of Middle Kingdom in Fayum Medinet Madi, both in Egypt, and the ancient settlement of Khor Rori, in Oman. These three sites present very different characteristics and interpretative aspects. The tomb TT14 is an example of micro-intra site, a small and narrow space with a very complex stratigraphy; the Temple A is an architectonic context; the archaeological landscape of Khor Rori is correlated with environmental studies. This variety of conditions of the archaeological contexts has required the use of different integrated technologies of data acquisition, elaboration and representation: scanner laser, computer vision and topographic relief for TT14 ; GPS, total laser station, GIS, remote sensing, photogrammetry, computer vision, 3D panorama for the settlement and the landscape of Khor Rori, 3D computer graphics on the base of topographical relief for the Temple A of Medinet Madi.

A collection of metadata, interpretative layers, multimedia contents are linked to models and integrated in the three-dimensional space, in order to develop the historical, architectural and archaeological interpretation of cultural contexts. All these data converge in a virtual scenario in the web where the scientific community can meet and interact in real time, exchange and test hypothesis, share data and make simulations in the 3D space. This virtual space will be an editable and dynamic environment in continuous evolution. 3D models are not closed and no longer accessible from users, as in most part of VR applications, on the contrary, they are open to continuous possible re-elaboration; they can be disassembled and recomposed according to different combinations and solutions. The models can be also exported from the application in "obj" format and re-used for different purposes. Users can use many tools to create new contexts or to modify the existing virtual environment: they can load single objects (.nmo format) or a complete scene (.txt format), they can load new textures applying them to 3d objects (fig.1), move objects, hide, show, delete objects, save their own scene, export object (.obj format), switch to other views/camera, create and move new lights, take measure (line, perimeter), create a link to metadata (web pages, movies, audio comments, texts, images...), move avatar in the 3D space, chat (fig.2).

Beside the 3D models of architectures and archaeological structures, obtained from topographical relieves, the VR application introduces other kinds of ontologies such as the "Virtuoteca" an imaginary cyberspace, like a library, where users can find digital contents, papers, multimedia related to the archaeological site and studies; the *virtuoteca* is also the place where objects and finds whose original location in the archaeological site is unknown, are recontextualized and exhibited (fig.3).

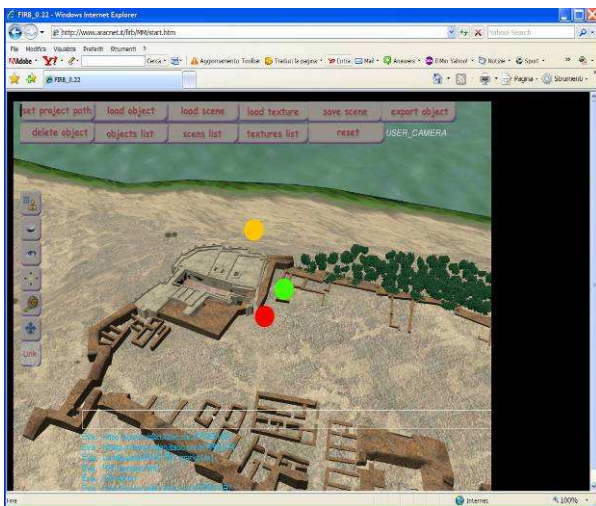


Figure 2: Chatting web community in the site of Kbor Rori, Oman.

Every new version of the virtual environment can be saved and uploaded on the web as a new "space" of the MuD, so that many different informative worlds can coexist and be compared in real time. The possibility to load, share and interact with data in the same spatial virtual environment can increase the level of learning and scientific communication. Even if the project focuses on these three archaeological sites it is in effect open to

any kinds of data, resources and study cases. Users need only to set the project path in order to indicate to the software the server address where the resources have to be loaded.



Figure 3: Virtuoteca dedicated to the site of Teban Tomb 14, Gurna-Luxor.

The only condition is that resources have to be saved with the compatible format and organized in a repository according to a clear criterion. The future development of this MuD and of virtual spaces will be based on continuous activities of uploading and sharing of resources, files and models. The application is developed in Virtools DEV, a real time rendering engine, and Virtools Mutiuser Pack.

A possible scenario is the virtual classroom where the teacher can interact in 3D with the students, discussing about key features of the archaeological sites, interpretations, hypotheses and general overviews. The final aim is to validate the interpretative and reconstructive process and to share all the activities with the rest of the community/classroom. The application could be a very useful tool also for planning, design, construction of conceptual maps, simulation.

4. Virtual Rome

Virtual Rome¹ represents an example that embraces both a high-end technological approach for the presentation of 3d cultural information and a scientific work on landscape reconstruction about the territory of Rome. The goal of this project is the creation of an on-line interactive and real time application dedicated to the exploration of the archaeological landscape of the city and its potential aspect during Roman Imperial times (2nd AD). The way the reconstruction is built and made available, is through a back-end environment: a 3d Content Management System, which includes a 3d plug-in, OSG4WEB, for dynamic editing (PESCARIN ET ALII, 2008).

The project, started in 2006, with the partnership of the Virtual Heritage Lab of CNR ITABC in Rome and CINECA

¹ Virtual Rome is available at www.virtualrome.net

Supercomputing Center in Bologna. Virtual Rome has developed an Open Source web VR application, based on geospecific data, 3d models and multimedia contents. The final purpose is the creation of a three-dimensional on line environment, embedded into a web-browser, where final users can interact dynamically in the reconstructed space and activate different behaviours in order to enhance their knowledge of the territory.

The back-end environment has been developed as to involve different researchers in the process of landscape reconstruction, inside a cooperative environment. The creation of this section allows to manage the project as a real archaeological 3d on line laboratory, on landscape reconstruction. On the other side, visitors who wish to explore archaeological landscape, trying to understand how should have been in the past need to have a space to visualize it interactively. Some functionalities have been developed, to help the user to better understand and move in 3d in the archaeological landscape: switch, pick, path and view points.

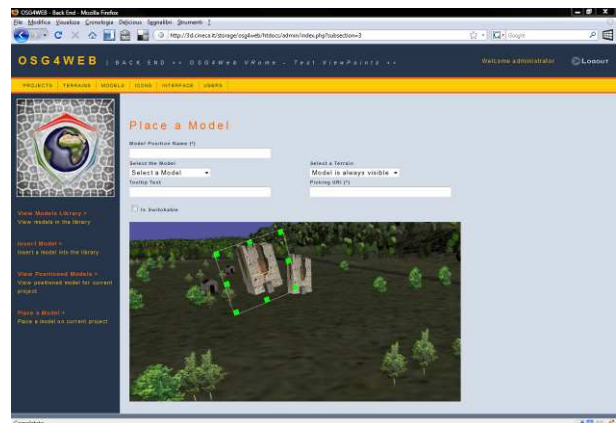


The project enhances the possibility to compare different terrains, each one with their ecosystems and models, moving through time or interpretative level, but maintaining the same spatial dimension, exploring the space at different scales and resolutions, activating different behaviours. To better share information and let paleo-environmental experts, archaeologists and architects to work together, we start developing the CVE. The original purpose was to cooperate in reconstructing the landscape, but also in defining what should be visible for final users. We would like to involve modellers and GIS experts in the process, making them aware of visualisation and integration problems. The back-end section, available to registered super-users, has been developed combining a Content Management System structure, based on Php and MySQL, and a 3d plug-in, OSG4WEB. The plug-in was developed using the OpenSceneGraph library (www.openscenegraph.org), and it is based on a previous project, published in 2004 and 2005 (FORTE, PIETRONI, PESCARIN 2005).

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References



5. Conclusions

Since there are still a few examples of embodied communities in archaeology, it is important to encourage the multidisciplinary methodological research to create new pipelines, new languages, new approaches able to validate interpretative processes and communication.

In the paper two study cases have been presented. The *FIRB project* is VR multiuser domain oriented to scientific research, interpretation and education, conceived as an open laboratory where it is possible to test advanced behaviors, actions and methodologies, to compare and investigate new relations among data in space and time. The continuous feedback of users determines the progressive update of the interpretative model, developing new directions and perspectives. Final aim of this project is not to produce a final result, a closed model, a definitive virtual museum on line. On the contrary the purpose is to create an open space for archaeological interpretation and discussion, able to manage any kind of models and to host many other projects. The Virtual Rome project has developed a VR webGIS application, with front-end and back-end on line solutions, for the interpretation, reconstruction and 3d exploration of archaeological and potential past landscapes of Rome. The purpose is the creation of a three-dimensional Open Source 3d environment, available on line, embedded into a web-browser, where final users can interact dynamically in the 3d reconstructed space and activate different behaviours in order to enhance their understanding of the territory. The back-end version has been developed as to involve different researchers in the complex activity of landscape reconstruction.

- ANNUNZIATO M., BONINI E., PIERUCCI P., PIETRONI E. (2008): "Cultural mirrors: an epistemological approach to artificial life for cultural heritage communication", in *Proceedings DMACH 2008, Digital Media and its Applications in Cultural Heritage*, 3-6 November, 2008, University of Petra, Amman, Jordan.
- FORTE M. e AA.VV (2008). "La Villa di Livia, un percorso di ricerca di archeologia virtuale", ed. Erma di Bretschneider, Roma.
- FORTE M, PESCARIN S., PIETRONI E. (2005): "The Appia Antica Project". In *The reconstruction of Archaeological Landscapes through Digital Technologies*, Forte M. Ed., BAR Int. Series.pp. 79-92
- GEROSA M. (2006): *Second Life*, Meltemi, Rome
- JONES Q. (2003): "Applying Cyber-Archaeology", in *Proceedings of the eighth European Conference on Computer-Supported Cooperative Work*, Helsinki, Finland, pp. 41–60. http://www.ecscw.org/2003/003/jones_ecscw03.pdf
- MATURANA H., VARELA F. (1980): "Autopoiesis and Cognition: The Realization of the Living", in: *Boston Studies in the Philosophy of Science*, ed. by Robert S. Cohen and Marx W. Wartofsky, vol. 42, Dordrecht (Holland): D. Reidel Publishing Co.
- PESCARIN S. ET ALII (2008): "Back to 2nd AD". In *VAST 2008 Proceedings.*, Braga Portugal, 2008
- SCHROEDER R. (1997): "Networked Worlds: Social Aspects of Multi-User Virtual Reality Technology", in *Sociological Research Online*, vol. 2, no. 4. <http://www.socresonline.org.uk/2/4/5.html>
- ZEKI S. (1999): "Inner Vision". Oxford Univ. Press.