SPATIAL DATA INTEGRATION IN REAL-TIME COOPERATIVE SYSTEMS

S. Pescarin

CNR ITABC, via Salaria km 29,300, 00016 Monterotondo St. (Rome), Italy - sofia.pescarin@itabc.cnr.it, www.vhlab.itabc.cnr.it

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ABSTRACT:

The paper presents some interpretation mechanisms, in the field of ancient landscape reconstruction. The goal will be the identification of adequate tools, already available or under development in the next future, which should help the interpretation process of ancient landscape. Different type of spatial data integration (raster spatial coverages, 3d models, vectors) will be also analysed. An approach oriented towards the use of a multidisciplinary methodology, characterized by the use of real-time 3d (VR) geo-spatial cooperative system, will be finally proposed. Landscape reconstruction, in fact, for its nature, requires a multidisciplinary and an interactive approach. It requires the contribution of different disciplines which have the necessity to maintain a continuous reference with spatial data and temporal dimension. Research in this field needs a place to share interactively knowledge and intermediate results, coordinating different works with the common goal of getting to a reliable and scientific result

The case study of Virtual Rome project will be described. This 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.

1.INTRODUCTION

1.1Visualisation and Interpretation

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

Interpretation means 'intermediary' or 'mediator' (from the Latin *intĕrprete(m)* made of *inter* and *pretium*) (Cortellazzo Zolli, 1999). 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*. Observation and cognition are part of the same process: both are active tasks. 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. While we see a scene, we create continuously schemes and categorizations, as to define essential and common characteristics. 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. Another important point is that our mind is interested in details, to bring them into a more general scheme. Unfortunately multiplicity hardly can be represented in a single visualisation, no matter the quality of the visualisation. We should be also aware that every interpretation is *personal*, since it is based on continuous comparisons with what is already stored in our brain. Nevertheless, the application of logic and scientific method, in the interpretation process, allows to get to valid results. There isn't a unique “true” situation or correct answer, especially when we deal with the study of the past (Zeki, 1999:4-23; Bateson, 1979; Maturana and Varela, 1984: 35-45).

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 (Pescarin 2008; Dramstad, Olson, Forman, 1996).

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 (Pescarin 2007).

1.2 Cooperative Environments

Collaborative Virtual Environments (CVE) are a class of networking applications that support collaboration between remote users, through a common spatial environment and using 3D graphics; CVE are updated as to reflect the actions and the movements of each of the participants. The goal is to build tools for communication and information share. CVE are different from distributed virtual environments (DVE), since they are focused more into collaboration and consistency in the cooperative work (Shao-Qing, Ling, Gen-Cai, 2004).

As described in the introduction, interpretation regarding ancient landscape should be approached in different ways, in order to be as much effective as possible. It should consider its spatiality and three-dimensionality, first of all. It should then allow an analysis of different constituting elements, maintaining the details, in the “de-composition” phase and the connection with original sources, in the “re-composition” phase. It should also let several data and disciplines to be used as to perform analysis regarding different aspects, such as geomorphological and botanical analysis, aerial photo-interpretation, remote sensing, archaeological survey and so on. Each discipline has its own characteristics and methodologies; it uses different sources, which are treated and processed differently (fig.1). It uses, moreover, different languages, making sometimes the cooperation very difficult. Each subject has its experts and their expertise have to be taken into account in the process, avoiding the mistake of considering an area completely autonomous. What do all these experts have in common? At least they have a couple of common perspectives: they insist on the same territory where they compare different sources (spatial perspective) and they communicate their interpretations through drawings (visual perspective) (Fig. 1).

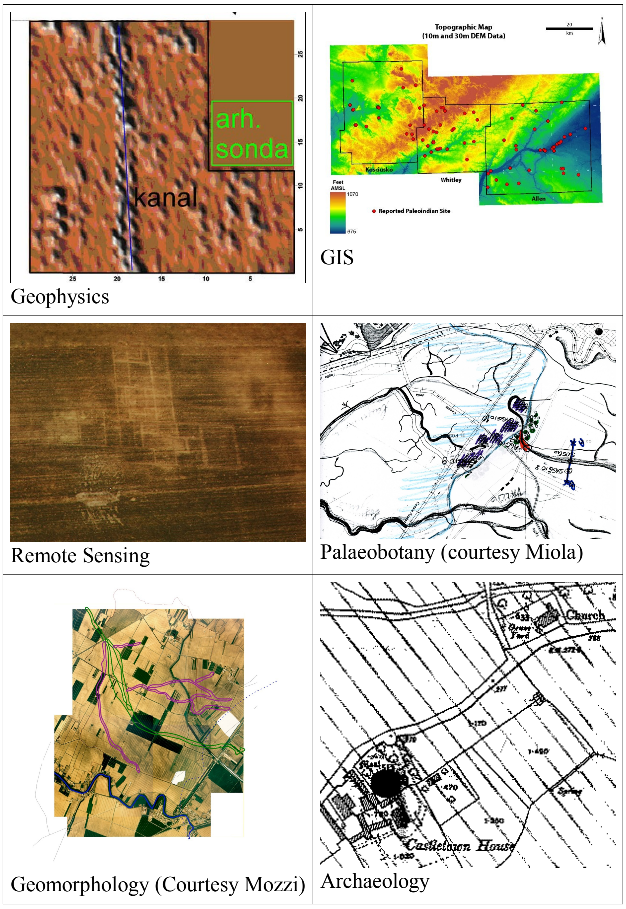

Figure 1 Different products of interpretation coming from different disciplines

Visualisation, if considered a final result and a collection of interpreted conclusions, will *never* become a useful tool for the research. While if it is regarded as an *open, interactive* process will really open up advances in the research.
A visual cooperative system can represent therefore a common 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.

1.3 State of the art

What kind of tools are already available and what can be further developed (and in which direction)?
In the last decade, I worked on several Virtual Reality projects, I could know some other, and I saw their potential for the research, if appropriately developed. Probably, in some cases, what was created for dissemination and public knowledge purposes, was not so adequate as it would have been for research aims. An excess of available information, all at one time, and disproportionate complexity of interaction mechanisms represent a failure regarding knowledge transfer (Antinucci, 2007).
I won't go into Virtual Reality applications dedicated to public dissemination, such as museum installations. I will try to define some characteristic that a 3d interactive tool should have, in order to be useful for an expert use, in the interpretation process of past landscape. For this reason I would focus the analysis towards research or working tools.
Today, Virtual Reality isn't any more treated as a communication and dissemination tool for cultural heritage, even thanks to International scientific conferences new interests (conferences such as From Space to Place, VSMM, VAST and CAA). It is aan useful tool for research (Barcelo JA., Forte M., Sanders DH, 2000; Pescarin, 2007).
While in the modeling, design or in the military fields there are several examples of CVE, there aren't as many examples in Cultural Heritage, and specifically in landscape archaeology. The reasons can be attributed mainly to three causes: the cost of these solutions, their complexity - lack of flexibility and also the lack of knowledge regarding their existence. Dealing with landscapes means having to deal with different data, such as: 3d models of different dimensions and resolution, detailed 3d terrains, high resolution geospecific images, vector thematic layers, vegetation, natural characteristics, etc. Each one has different characteristics. Each characteristic become a problem, when we need to implement it into a VR system. MultiUser and On Line access amplify the problem.
There are several successful examples of products and projects already available. Unfortunately they treat just a partial aspect, with respect to what is needed by landscape archaeology.
Social Networks, such as Second Life, demonstrated the potentiality of such tools, independently by some enthusiastic overflow (Gerosa 2007). Recently, a not 3D network is spreading so incredibly rapidly: FaceBook. With million of members, its success is attributed to its structure. First, it has been designed for college students, *by* college students. Second, it allows information wide spreading but also *privacy*: you can *trust* it. Third, it emphasises *clusters* (socio-economic) and groups, even thanks to low-involvement communication. And last but not least simplicity, speed (Baloun 2006). Wikis are also commonly used in the cooperative work of projects developments.
Computer Game industry, on the other hand, has reached extraordinary results in the creation and distribution of multi-user game (sometimes) cooperative environment, such as MuDs.
While high resolution 3d models on line browsing are still an open problem, for 3d terrains Google Earth, in its stand alone version, is surely a reference point[1]. The rapidity high resolution spatial imagery loads, makes it so successful. Moreover it can integrate vectors and low-resolution 3d models. Recently, even

[1] Recently, Google presented Google Earth Plug-in: a new project to embed in the Internet browser the application ((http://code.google.com/intl/it-IT/apis/earth)

Rome Reborn project has moved to Google as Ancient Rome 3d layer (Frisher et alii 2008).

Recently, VHLab team at CNR ITABC has been involved in three projects, whose goal was the reconstruction of ancient landscape: a FIRB project on Robotics and Virtual Environments (Forte, Pietroni, Dell'Unto 2008), Virtual Rome (Pescarin et alii, 2008; Calori, Camporesi, Forte, Pescarin, 2008) and Ca' Tron projects (Bondesan et alii, 2007;). In these projects, as archaeologist, I could experience personally the complexity of a real multidisciplinary approach. For this reason, we have been pushed to experiment a more efficient approach, testing and developing examples of low-cost on line Cooperative Virtual Environments, based on Open Source and Commercial software.

The FIRB project has developed a multiuser cooperative environment, available on line, which enables researchers to work together in the reconstruction of archaeological sites. It is based on VirTools Dev and it's available on line, with a common Internet browser (Fig.2).

Figure 2 . Firb Project (courtesy of E.Pietroni)

Virtual Rome project has developed a Cooperative Environment based on Open Source tools.

2.VIRTUAL ROME

2.1 Roman Mindscape

When Pablo Picasso was drawing its “Parade” in 1917, he was probably looking at some hills, in the southern part of Rome (fig. 2). Although it might seems peculiar to start describing a project related to Virtual Archaeology and Rome with Picasso, it has a connection with the way the work has been developed. The composition represented in the drawing is the mindscape, with the landscape visible from the Stage and the upside-down perspective of the Scene. In the “Stage” the actors - archaeologists, paleo-environmental experts and programmers - work together to reconstruct the archaeological and ancient landscape, with its monuments, its relations with the original context. They build up also the on-line visualisation project, with specific communication target. In the “Scene”, the Internet Scene, the landscape appears in its four dimensions and visitors can dynamically explore them, interacting with its components and its information.


Figure 3 Picasso, *Parade*, 1917.

Virtual Rome 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 (2^{nd} AD) (figure 3). 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, has been directed by the writer and by Maurizio Forte, with the partnership of the Virtual Heritage Lab of CNR ITABC in Rome (IT) and CINECA Supercomputing Center in Bologna (IT): a group of ICT and GIS experts, archaeologists, art historians and architects devoted to VR applications, dedicated to Virtual Heritage. It was sponsored by Seat Yellow Pages and the Roman Chamber of Commerce.

Virtual Rome has developed an Open Source web VR application, based on geospecific data, 3d models and multimedia contents, with front-end and back-end on line solutions, for the interpretation, reconstruction and 3d exploration of Roman landscapes. 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 (Dramstad et alii, 1996; Renfrew 1994; Pescarin S. 2008). 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 (Forte, Pescarin, Pujol Tost 2006). 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. Switch functionality enhances the possibility to compare different landscapes, changing the terrain base, maintaining the same perspective and geographical position. Picking of 3d objects allows to activate multimedia contents dedicated to a more detailed explanation. Automatic paths and direct pre-recorded view points regarding specific monuments.

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. We noticed in fact that different modellers, especially if remote, used to create very diverse models, even if we provide a training at the beginning. Even GIS experts tended to produce not homogeneous results (i.e. tiles with different resolutions, different formats or coordinate system). . Training

is certainly crucial, but also a direct experience and involvement deep in a project can help.
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; Calori et alii 2005).
After an analysis of different open source projects and 3d graphic toolkits, it was decided to base the work on OpenSceneGraph, the only library that in that moment was offering paging support for terrains and on-line publication capabilities, through the .net plug in (Kuehne Martz 2007). The developed plug-in, OSG4WEB is available under the GPL, for Internet Explorer and Mozilla Firefox. It has the following characteristics: paged geospatial dataset support,coordinate and projection handling, large 3d terrain dataset management, 3d models integration, natural elements (such as vegetation) integration, vector layers integration, on-line 3d data publication and interaction, Fly and walk navigation tools, terrains or models switching, vector information and 3d models loading, picking and loading of multimedia contents, environment integration. The project followed two main directions, regarding contents and software development

Contents were studied and developed in accordance with scientific and archaeological issues and with on-line interactive publication in the virtual reality environment. The work required several activities: archaeological landscape and ancient potential landscapes reconstruction; 3d models creation, optimization and integration in 3d scene; ancient potential vegetation map creation and vegetation integration; remote sensing analysis of aerial photomosaic (20 cm resolution); multimedia contents creation, integration and connection with 3d models.

2.2 Archaeological and Ancient Potential landscapes reconstruction

The CVE enabled to reconstruct and represent potential Roman landscape, through the integration of different sources, the definition of models to be loaded and the identification of contents connected to 3d models. The entire process is completely updatable and editable, apart from the 3d terrain that needs to be pre-processed to be handled on line as paged.

Archaeological landscape was created from an initial GIS archive. Thanks to the co-operation of Seat Yellow Pages, we could use a detailed aerial photo campaign by Nuova Telespazio, 20 cm resolution, available for the entire city of Rome. Geoimages were all projected in the same coordinate system (WGS84 UTM32N). The available Digital Terrain Model, was then used with the entire geoimages dataset, to build the three-dimensional terrain with OSGdem. It is a simple and tool, useful to creaate the entire hierarchical structure of the final output. The final output was a 3d model of the entire area, divided, both geometry and texture, into different Level of Details (LOD). All vector thematic layers related to archaeological landscapes were also created into a GIS software: location of archaeological sites, Roman road and river system, etc. Those layers represented all known and reliable information about the Roman period in the area, coming mainly by archaeological excavations and surveys, aerial photo interpretation and geoarchaeological observations. For each vector layers was created a database record, with information regarding sources and reliability level. In order to reconstruct Roman Landscape, it was necessary to add other information. Soil map, litho-stratigraphic and geological maps of the city have been acquired and modified in order to define different Environmental (Roman) Classes. The Rome Soil Map was particularly useful, since it has been developed, by Rome municipality (Volpe and Arnoldus-Huyzendveld 2005), after a long “land evaluation” work, including “land capacity classification” (LCC). The dominant soil use of each area was reconsidered and its shape modified, on the base of comparisons with Roman geomorphology, on the analysis and evaluation of known Roman archaeological sites. In this way the territory around Rome was divided into different Potential Environmental Classes, accordingly with different land capacity values.

A new map, the Roman Potentiality Map, was thus obtained. To each class was then assigned a specific Ecosystem, identified by several sub-categories. Visual Nature Studio was used to create and export in GIS format, the reconstruction. A Roman Vegetation Library was also created and included in the CVE, containing species whose presence is known during Roman times. To each ecosystem was than assigned a specific vegetation type (fig. 4)

Figure 4. Rendered reconstruction of Roman Potential Landscape.

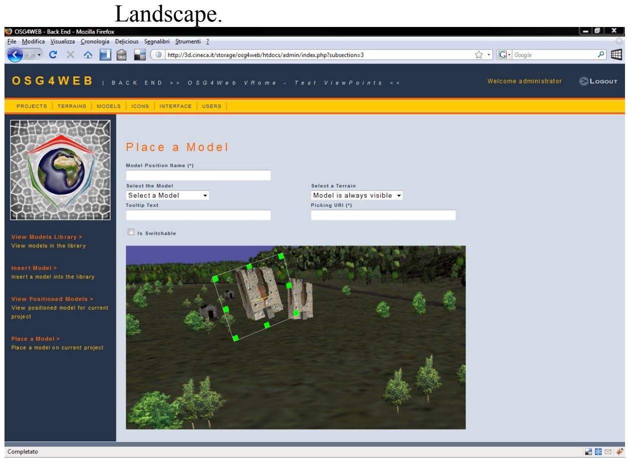

Figure 5. Cooperative Environment of Virtual Rome project

3D models were built, mainly from scanner laser data. They have been optimized, subdivided into small geometrical pieces , each one with different levels of detail. All the models have been added to the CVE model library, by modellers themselves. They also “place” the monuments in the landscape, updating the front-end visualisation. At this point the result was visible to the entire team. Reliability, but also performance, could then be evaluated. Thanks to the graphical interface, non-programmers can explore the territory, moving from a dataset to another one, comparing changes, querying interpretation and source information. Each time they can add new models or modify existing ones, etc. In this way, in a sort of digital “anakyklosis”, the interpretative and reconstruction work doesn't finish.

3.CONCLUSIONS

Although the CVEs presented aren't probably enough stable yet, they represent a promising and very useful technology. Modifications and further developments are needed in the future, taking some lessons from previous experiences and different projects (§1.1, 1.2 and 1.3).

Some conclusions (as landscape archaeologist). First. We need tools that help the categorization process, even through the connection with databases. Second. We need tools and methodologies which contribute at maintaining details (immoderate simplification can preclude a real comprehension); reconstructions should present detailed visualisations, in term of resolution and precision. Third. Interactive systems are effective, if carefully developed; through interactivity, it is possible to create new perspectives and situations, thus arising new questions. Fourth. We need to share information in a communicative and easy way, through on line access where it is possible to start working sessions and access common repositories. And fifth. We should consider that successful projects often start from people who needs those project.

4. REFERENCES

Antinucci F., 2007, Musei virtuali. Come non fare innovazione tecnologica, Laterza Ed.

Barcelo JA., Forte M., Sanders DH, 2000. Virtual reality in archaeology - ArcheoPress, Oxford (British Archaeological Reports, International Series 843)

Akenine-Möller T. , E. Haines, 2002, Real-Time Rendering Second Edition, pp.477-479, A K Peters Natick, Massachussets US, 2002

Baloun K., 2006, Inside Facebook: Life, Work and Visions of Greatness.

Bateson G., 1979, Mind and Nature. A Necessary Unit, Dutton, New York.

Bondesan A., Bonetto J., Busana M.S., Kirschner P., Miola A., Mozzi P., Pescarin S., Villani M.C. 20,000 years of landscape evolution at Ca' Tron (Venice, Italy): palaeoenviroment, archaeology, VR webGIS, in *Proceedings of “Hidden Landscapes of Mediterranean Europe: Cultural and methodological biases in pre- and protohistoric landscape studies”* Siena, May 25-27, BAR Int. Studies, 2007

S. Pescarin, L. Calori, C. Camporesi, M. Forte, A. Guidazzoli, S. Imboden, Open Heritage: an Open Source approach to 3d real-time and web-based landscape reconstruction. In *VSMM2005. Virtual Reality at work in the 21st century, Proceedings*, Oct. 3-7 2005 Ghent, (Thwaites Ed.) Budapest 2005, pp.313-320

Cortellazzo Zolli, 1999. Dizionario etimologico della Lingua Italiana, Bologna 1999

Dramstad, Olson, Forman, 1996, Landscape Ecology Principles, Washington, DC, Island Press 1996

Forte M., Pietroni E., Dell'Unto N. 3D Multiuser Domain and Virtual Ecosystems for Transmission and Communication of Cultural Heritage. In *DMACH 2008, Digital Media and its Applications in Cultural Heritage*, College of Architecture and Arts, Univerity of Petra, Jordan, 3-6 November, 2008, University of Petra, Amman, Jordan.

Forte M., Pescarin S., Pujol Tost L., 2006. VR applications, new devices and museums: public's feedback and learning. A preliminary report. In *VAST 2006 Proceedings, Short Presentation*, Archaeolingua Ed.

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

Frisher B. et alii, Rome Reborn, in *Proceedings of Siggraph 2008.*

Kuehne B., Martz P., 2007, OpenSceneGraph Reference Manual ver. 2.2, Skew Matrix Software and Blue Newt, 2007

Maturana and Varela, 1984. L'albero della conoscenza. Garzanti

Pescarin S., 2007, Reconstructing archaeological landscape. Interpretation and integration in spatial and real-time open system. In *Space - Archaeology's Final Frontier? An Intercontinental approach*, ed. D. Keeler, R. Salisbury, Cambridge Scholars Publishing , ISBN: 9781847182784, Cambridge 2007

Pescarin S., 2008, Explicit theoretic pipeline: GIS analysis and data integration for archaeological landscape reconstruction, in *CAA2008,* Archaeolingua, Budapest, in print.

Pescarin S. et alii, 2008. Back to 2nd AD. In *VAST 2008 Proceedings.*, Braga Portugal, 2008.

Renfrew C., 1994, Towards a cognitive archaeology, in *The Ancient Mind: Elements of Cognitive Archaeology* (Renfrew, Zubrow eds.), Cambridge 1994, pp. 3-13

Shao-Qing W.; Ling C.; Gen-Cai C., 2004. A framework for Java 3D based collaborative virtual environment, in *Computer Supported Cooperative Work in Design, 2004. Proceedings. The 8th International Conference* on Vol. 1, pp: 34-39

Volpe R., Arnoldus-Huyzendveld A., 2005. Interpretazione dei dati archeologici nella ricostruzione storica e ambientale del paesaggio suburbano: l’area di Centocelle nel suburbio sudorientale. In *Roman villas around the Urbs. Interaction with landscape and environment. Proceedings of a conference at the Swedish Institute in Rome*, Sept.17-18, 2004; Rome 2005.

Zeki S., 1999. Inner Vision. Oxford Univ. Press.

Virtual Rome web site: http://www.virtualrome.net

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