OPENHERITAGE: AN INTEGRATED APPROACH TO WEB 3D PUBLICATION OF VIRTUAL LANDSCAPES

L. Calori[a], C. Camporesi[c], S. Pescarin[b], M. Forte[b], A. Guidazzoli[a]

[a] CINECA via Magnanelli 6/3, Casalecchio di Reno – BO, Italy - ([l.calori], [a.guidazzoli]@cineca.it)
[b] CNR ITABC (Institute of Technologies Applied to Cultural Heritage), via Salaria km 29,300, 00016 Monterotondo St. (Rome), Italy ([maurizio.forte],[sofia.pescarin]@itabc.cnr.it, www.itabc.cnr.it/VHLab)
[c] University of Bologna, Dept. Computer Science, Bologna-Italy (carlo.camporesi@gmail.com)

KEY WORDS: visualization issues for large and complex sites: Applications in cultural heritage

ABSTRACT:

The OpenSource approach offers today new possibilities in the field of Cultural Heritage. New 3D tools are now available and particularly useful for real time and 3D reconstruction of archaeological landscape. The processing of geographical data, GIS and Remote Sense data can be completely maintained even in the creation of Virtual Reality Applications. The paper describes the application (desktop and web) of tools such as OpenSceneGraph and Virtual Terrain in the case of the Archaeological Park of Appia Antica (ancient via Appia, Rome - Italy).

1. INTRODUCTION

1.1 Complexity, connectivity and communication

Archaeologists, historians, art-historians, have often to face, in their research activities, problems related to the complexity of sites or monuments. In the study of the ancient landscape it's quite common to use data coming from historical archives, from ancient sources, from the observation of the archaeological landscape, that is also what we perceive today. These kind of data are usually integrated with those obtained in the fieldwork, during excavations and/or mapping activities (architectonic and topographical survey with DGPS, Laser Total Station, today even Laser Scanner), and with those processed in the labs with remote sensing, GIS, Archaeometric techniques (Fig.1).

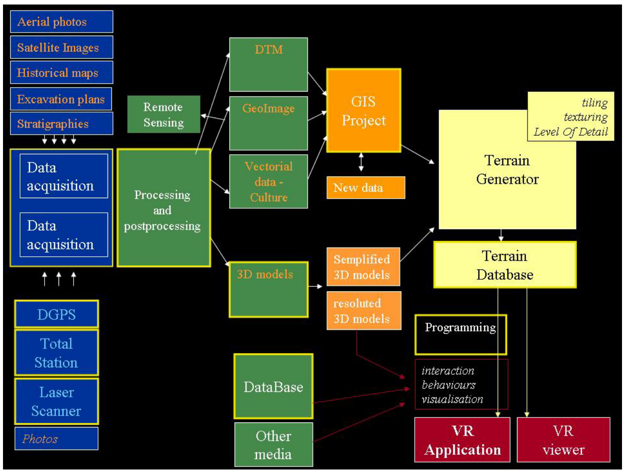

Figure 1 Scheme of the entire process from acquisition to VR application

What we are obtaining, even thanks to the precision of new instruments (such as DGPS and Laser Scanner) and the resolution of some available sources (high resoluted satellite images and so on), is such a quantity and quality of information, that even the logical and cognitive process of elaboration and communication of that information has to change. On one side, this means that we need to compare data at different levels of details and at different scales (cartographic raster and vectorial data, remotely sensed images, texts, digital pictures, radar images, more or less detailed 3d models, Archaeometric data, and so on), analysing relationship and producing new data to perform more advanced analysis. On the other side we are forced to create interdisciplinary groups in order to face this complexity and variety.

There are many technological tools already available that can really help managing this complexity, to do analysis, to archive data, and so on. Cultural Heritage field is quite familiar with data and information so different in typology, so widespread in space and time. We have often to deal with archaeological remains that are spread off, sites and monuments that have completely lost their original context, excavations made decades or even centuries ago; in some cases we have completely lost any memory of the past and many archaeological landscapes are actually in danger of disappearance. The future of Cultural Heritage [see Digicult Reports:2003 and Digicult Thematic Watch Reports:2004] it's not just related to its preservation, but it's also connected to their diffusion and wide-spreading for the international communities. The Web is the perfect medium to publish data, opening to large public participation.
In our opinion, just advanced systems can be capable to deal with this complexity, offering in the meanwhile the opportunity to communicate it.
In this sense we have found that Virtual Reality Systems are an answer, especially if they are though in a communicative way and designed as spatial environments.
Virtual Reality Systems can help not only the communication, in a didactical approach, but also the research activity itself. Inside a 3d, real time, spatial and georeferenced environment, elements under investigation come up more easily, sometimes it's possible to get to conclusions in a shorter time and to compare in the same inclusive space different information.
Moreover VR helps to explain complex concepts in a easier way, as we have seen in some DVR (Desktop Virtual Reality) applications realised in the past (Navigation in the archaeological landscape of Aksum, Virtual Bononia,

Scrovegni Chapel VR installation: See Forte, Pescarin 2004). In fact with a VR system it was possible to recreate lost contexts, gathering, putting together and organising different kinds of data, overlaying them. This allows to reflect over main historical and archaeological topics, but also minor everyday issues. A real time and interactive system can help to give some answers, letting new questions to come up, while a web shared application can help to diffuse cultural information.
The Virtual Heritage Lab of CNR ITABC has dedicated part of its research efforts to the creation of 3d spatial archives, in a process aimed to integrate different technologies, data and skills, in a unique process that goes from fieldwork activities (mainly mapping with DGPS and 3d data acquisition with Scanner Laser) to data post-processing.
What we need to do in order to create such a VR system, first of all, is to make all the data 'comparable' in overlay, opened to complex queries. One of the aim, in fact, is to compare information, analysing their relations, connecting them, creating new information. This can be achieved easily if the spatial component of the data is kept as crucial.
A GIS project has to be constructed at the bottom of all the following working phases. Databases have to be carefully planned in connection with vectorial and spatial information. 3D models can be freely modelled but with a particular attention to their use in real time and in the web (and they need to have a geographic correspondence in the GIS such as point or polygon).

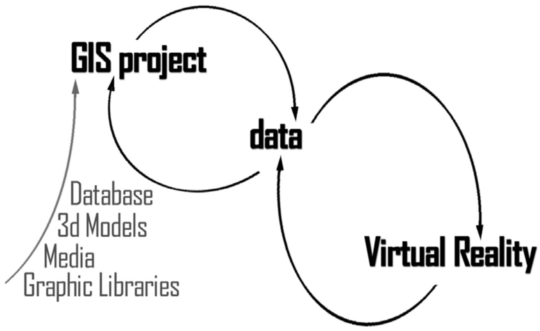

Figure 2

Figure 2 describes the process.
In the GIS data useful for VR application are prepared: DEM (Digital Elevation Models), Geoimages (airplane or satellite images, etc) and Culture data. With "Culture" we intend all the thematic vectorial layers that can describe a landscape, such as rivers (lines), roads (lines), trees (points), fields (polygons), etc.
Thanks to the spatial component of the data, it's possible, inside a VR system, to do some analysis and interpretation of those data and create new information that can be transformed into new layers back in the GIS, starting something like a "virtuous circle" that connect the bottom-up and top-down approaches [Forte, Pescarin 2004].
More open is the process more virtuous are the results.
What we would like to obtain is a Virtual Reality application based on Geographical Information Systems, that gives also the possibility to exchange information, to share data, to open discussions, to test different hypothesis and eventually to revise some of them.
OpenSource gave some solutions since it's first adoption in some archaeological projects. Furthermore we are both, CNR ITABC (the Institute of Technologies Applied to Cultural Heritage, with its Virtual Heritage Lab dedicates most of the research efforts towards the mapping of archaeological sites and the reconstructions of ancient landscapes with VR and spatial systems: www.itabc.cnr.it/VHLab) and CINECA Visit Lab (www.cineca.it/sap/area/laboratmultimod.htm) convinced that OpenSource is a challenge for the future of Cultural Heritage.

1.2 State of the art: virtuality and OpenSource

When we start working in the field of Cultural Heritage, we noticed that "thinking in 3D" was not so common as we could expected from scholars used to work with landscapes, artefacts, sites, and so on. Connected to this aspect we noticed, even analysing our personal experience, that so little questions were made. 3D real time environments can help to reconstruct ancient landscape, while an OpenSource approach can push towards a shared working method.
Virtual Reality, as an educational tool, is evolving through the prototyping stage, aspiring to become an everyday instrument.
The application of Information & Communication Technologies (or, more specifically, Virtual Reality) to Cultural Heritage can certainly be deemed as one of the new frontiers of cultural policies. In particular, the idea of using visualisation as an interactive interface for accessing cultural database is very promising.
Sources and documents, organised inside a multimedia database, get to the final user through the virtual interface in a continuous and bi-univocal interaction between virtual reconstruction and historical, artistic and archaeological documents.
However, experimentation is not a concluded process and it is particularly important to develop meaningful applications, capable of satisfying the requirements from an extended range of users. Such applications should offer not only flexibility, from the usability point of view, but also portability, hence enabling the application to run on many different visualization platforms available today.

These aspects clearly came out in the two projects we realised constructing the VR system: Appia Antica Project and Certosa Project.

2. CASE STUDIES

2.1 The Appia Antica Project

In the case study of the Appia Park project (the archaeological park of the Roman Via Appia), followed by the interdisciplinary team of CNR ITABC and Rome Municipal Superintendence, an intense activity of archaeological and architectonic survey (topographical and architectonic mapping and "micro-topographical" and "micro-architectonic" mapping) was done in order to acquire data for a real-time spatial interactive system. All the techniques used (DGPS, Total Laser Station, 3D Scanner Laser, 3D Stereo Photogrammetry, Photo Modeling Techniques) were integrated, while the entire set of data acquired was post-processed, overlaid in a GIS project based on their spatial reference, connected with external multimedia databases. Even 3D information was geo-located and processed in order to be used - together with GIS data, Digital Terrain Models and Geoimages – inside a Desktop Virtual Reality environment, based on Virtools (www.virtools.com) for the off-line application and on OpenSceneGraph (www.openscenegraph.org) and VTerrain (www.vterrain.org) for the on-line VR application (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 3dimensional, interactive and flexible way. At the same time, this approach allows 'scaled' version, useful even for cultural content dissemination, at different level, without loosing any scientific precision.

2.2 Certosa Virtual Museum and VEL project

The project New Institutions for Communicating the City, of Bologna City Council and CINECA are currently developing a complex VR application regarding several cultural sites of the city that will constitute the basis of a Museum for Accessing the City of Bologna.
The immersive navigation inside 3D interactive virtual models (city of Bologna, Certosa, Etruscan landscape, Cloister III, Partisan's Ossuary, Monument to the dead soldiers of the Great War, Memorial to the dead in the Liberation War) guides toward data and meta information. Sources and documents, organised inside a multimedia database, get to the final user through the virtual interface in a continuous and bi-univocal interaction between virtual reconstruction and historical, artistic and archaeological documents.
The project can be seen as a centripetal force attracting the efforts of several Institutions, with cultural contents pertaining to different historical periods, integrating the output with cross media technologies that reach final users, divided into different categories.
The fundamental idea of this case study is visual mediation. Thus an interactive visual portal has been conceived to allow easy access to historical and cultural contents. Choices are guided by vision and the virtual environment presents information in a user friendly manner. The actual territory that the application can visualize is the second most important concept around which the application revolves.
This aspect enables a user to put into relation different historical events and topics, gathered under the same contextual "roof" that unifies even apparently disjointed cultural resources. The interaction with the virtual environment allows users to be immersed in a sort of *hic et nunc* but, at the same time, it permits them to retrace and understand historical events which occurred in the same area at different periods. We have used a VR application based on SGI Performer to realise the virtual museum of the city, but we are now experimenting a new version of the museum, based on OpenSceneGraph and Virtual Terrain.
We found that this approach was quite useful to create a shared 3d environment used by CINECA and Archaeological Museum Team. In fact inside VT Enviro it was possible to reconstruct dynamically in real time and directly in 3d how the actual landscape could appear during the Bronze Age.

3. OPENSOURCE SOLUTION

3.1 An OpenSource solution for terrain modelling and landscape real-time reconstruction.

The application set developed for Web generation, reconstruction, navigation and fruition of three-dimensional landscapes, applied in a real time environment was possible thanks to the use and the increasing of some OpenSource libraries and the software included in the Virtual Terrain Project. VTP is an OpenSource solution that includes some tools for easily constructing any part of the real world in interactive, 3D digital form.

The first problem we have to face when we manage and reconstruct large territories is data dimension (in term of memory, number of polygons and textures).
At the beginning we had to choose whether to use an adaptive or static method for real time 3d terrain reconstruction. After a first analysis we found that OSG and VTP used in combination could be a good solution.
VTP project offers a series of tools for virtual terrain reconstruction. With these tools it's possible to prepare geospecific data, such as vectorial, geoimage, DEM, etc (with VTBuilder) and to visualise and modify them dynamically in 3D (with Enviro).

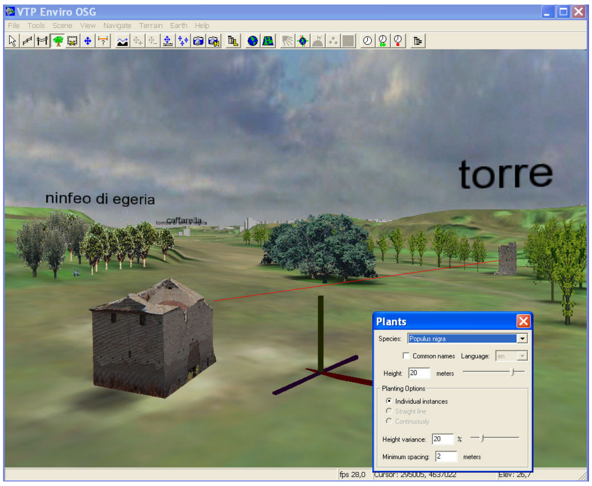

Figure 4. VTP Enviro and the Appia Park landscape

We kept on working on these two tools in order to obtain more complex behaviours and to get to a Web publication of complex landscapes, after their elaboration and modification in Enviro.
After a process of readapting and modifying VTerrain source code, the toolkit became not just a 3d and real time viewer, but a real platform for the creation, modelling and construction of geographic scenarios.
In order to open the software to as many formats as possible, we enabled the possibility to use terrains and models generated by other external programs (paged terrain, 3d photo-modelled objects, etc.). This allowed to take all the advantages of VTP kit, inside a wider and more effective working flow, and to create a medium useful to add, even on imported terrains, their own cultures, modifying and then exporting them in order to be used by other software. Another potentiality of VTP, is its flexibility to be adapted to different 3D rendering libraries, such as PLIB (Portable Game Libraries is object-oriented C++ interface based on OpenGL for graphics 3D applications: plib.sourceforge.net), SGL (SceneGraphicsLibrary consists of a set of cross-platform C++ libraries, built on top of OpenGL, which implements 3D scene graph functionality: sgl.sourceforge.net) and OSG (OpenSceneGraph is an OpenSource, cross platform graphics toolkit, based on OpenGL, for the development of high peformance graphics applications: www.openscenegraph.net).

Regarding the 'terrain - creation' platform used for the import and export extensions, the configuration used was just OSG because, in comparison with the other known libraries it had some interesting peculiarities:
First of all it can manage a large set of data formats that comprehend the most used 3d, images, streaming, formats;
Secondly OSG is a cross-platform that can be transferred easily toward other different architectures, windowing system

independent. At last it's a scalable architecture that can be used on different computers: simple PC until powerful graphic workstation, like SGI. Moreover it can fully take advantage of multi-processor and multi-pipe systems characteristics. Furthermore OSG can manage even terrain datasets created by osgTerrain library (Internal library of OpenSceneGraph framework for terrain generation), a really powerful tool that produces a three-dimensional territory, using a static generation technique, maintaining initial data resolution, independently of the data size. With *Static methods* it's possible to generate, from elevation data and textures, static geometries at different resolutions. The created geometries will be subdivided into a hierarchy of Levels of Details switchable according to user position. If the technique used reflects the paging structure on the disk, the hierarchy can be saved in a file and loaded only when needed.

Using other OSG modules it is possible to access the data, even from a remote source. This potentiality was employed in the development of an ActiveX plug-in for Internet Explorer, that is capable of finding data, generated by VTP, in a web server, activating a real-time navigation on the scenario. Naturally accessing large territories through the Web (fluid navigation) means that virtual scenarios have to be carefully planned since the beginning, in order to generate light and paged models. In the case of Appia Antica project, either in the export phase either in the loading of the data through the Web, some tricks where thought in order to facilitated data loading such as: disk-cashing technique, use of instance models in the scene and generation of simple polygonal structures.

3.2 Export functionalities implementation

The idea of implementing a method of exporting culture data directly from a visualisation tool came from the study of OpenSceneGraph tree. Everything that is visualised during a rendering session has a structure that can be saved.

Thanks to the implementation of Enviro Code and to the presence of a library that extends OpenSceneGraph methods, it was possible to define exportable scene-nodes.

Three different method to export '*structures*'[1] data have been implemented. With the first one it's possible to export culture data as single files in .ive or .osg file format, the second one allows to export data according to a grid and with the last one a user can insert cultures directly INSIDE the paged hierarchy of the scene (in the tiles). This method allows to publish data on the Web.

There are different typologies of culture we can export: Vegetations, Buildings, Models, Vectorial Layes, Labels and Roads. The user can choose in the 3d environment offered by VT Enviro what to export and how to do it, letting the program modifying and reconstructing the SceneGraph, defining an optimized saving. In order to optimise operations on the structures, we use NodeVisitor technique[2]. Thanks to this OSG class, specialized *visitors* are created in order to get through and to model the SceneGraph, allowing correct export functions.

[1] We define *structure* as any culture data representing a 3d OSG object represented in the scene (i.e. buildings, vegetations, labels, etc.).

[2] NodeVisitor is a class of OpenSceneGraph Core. It applies *safe* operations to the scene graph, analysing the request nodes, stopping at the required nodes in order to be able to modify, delete them or insert new ones. NodeVisitor implementation in based on GOF Visitor pattern and it implements Double Dispatch algorithm [Gamma, Helm, Johnson, and Vlissides, 1994].

The operations applied to the NodeVisitors define:

- findings of the right tiles of a database paged terrain where structures have to be inserted
- definition of ProxyNode structures (as to avoid models replica)
- texturing of Building structures with geoimages (such as satellite image) mapped on the terrain surface.
- Saving of textures (in .osg format)
- Generation of textual labels using OSG BillBoard class
- Saving of terrain tiles files and other added files (archive files and so on).

3.3 Web 3d terrain data publication and interaction

In order to navigate inside remote on-line landscape we developed an Active-X, that can be integrated in any Explorer Browser (from version 5.0). It is used to load 3d models through the Web.

The Active-X was developed using OSG player internal and default methods. To manage source data it was used a Plug-in net included in OSG version 0.9.8.

Culture export (directly inside the paged terrain) functionality, as explained above, was realised exactly to obtain the kind of files useful to be loaded through the Plug-in.

Moreover, we used an integration of scripting language (PHP) and Database to control dynamically the scene rendered in the Active-X from web-pages. This allowed a more complete management and interaction with the scene. It is possible, indeed, to add new points of view, new 3d models, new thematic vector layers, and so on.

In the future we are planning to let the Active-X to communicate directly with Database information. This process need a different approach: it requires a continuous exchange of information from the Active-X to Web Pages (DataBase) and back again to the Active-X.

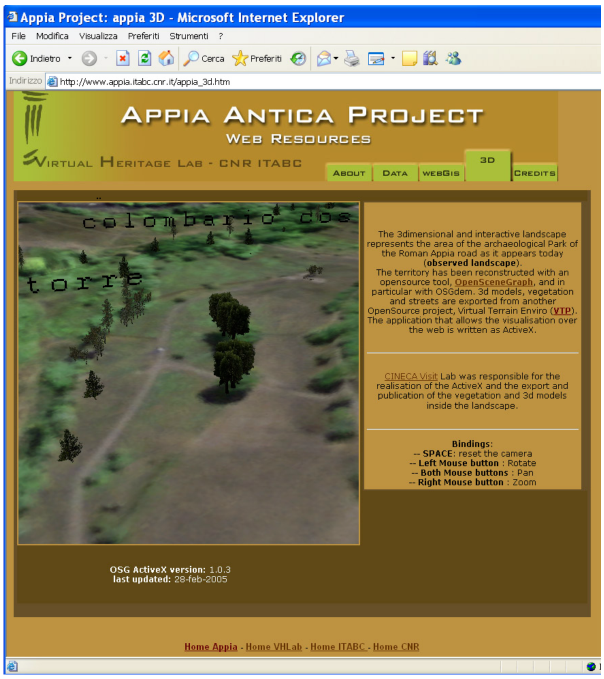

Figure 5. The landscape of the Archaeological Park of Ancient Via Appia published on the Web

4. CONCLUSIONS AND FUTURE DEVELOPEMENTS

After these experiences we are planning to go further on, toward a more ambitious and advanced project: the creation of a real "shared working system web-based". The complete system we would like to obtain, comprehends: a GIS repository based on an open source WebGIS; a 3D Models repository based on OSG, PhP and PostgreSQL; a plug-in viewer not only for Internet Explorer but also for other browsers; a more complete editing client with some added functions such as adding new buildings or trees in geographical position, taking them from the repositories; a server component to which is demanded the task of data distribution recalled by the viewer client and to accept and validate the insertion and variation requests; a rebuilding tool that periodically and/or on demand, activates a terrain re-generation procedure in order to apply the modified elements.
We believe that this kind of applications and this kind of approach will have more and more fields and benefits. Since 3D is a perfect communication factor, pushing, at the same time, development and comparison, a VR Web System could surely help Distance Learning, for instance, or Virtual Communities. Even in the case of Urban Planning it could be a concrete tool to promote citizens participation to cultural and planning politics of our Public Administrations and Nations.

5. REFERENCES

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

Calori L., Diamanti T., Felicori M., Guidazzoli A., Liguori M.C., Pescarin S., Valentini L., Mauri M.A., *Databases and Virtual Environments: a Good Match for Communicating Complex Cultural Sites*, in Proceedings of Siggraph2004

Digicult Reports 2002: *Technological Landscapes for Tomorrow's Cultural Economy* (www.digicult.info)

Digicult Thematic Watch Reports 2004: *Core Technologies for the Cultural and Scientific Heritage Sector* (www.digicult.info)

Felicori M, Forte M., Guidazzoli A., Liguori M.C., Pescarin S., 2005**,** *From GIS to Landscape VR Museums*, in **"**The reconstruction of Archaeological Landscapes through Digital Technologies", Proceedings of the 2nd Italy-United States Workshop, Rome, Italy, Nov. 2003, BAR International Series

Forte M. 1996 (a cura di), *Archeologia. Percorsi virtuali delle civiltà scomparse*, Milano, 1996

Forte M., Pescarin S., *The virtual reconstruction of the archaeological landscape*, in : XXIV Rencontres internationales d'Archéologie et d'Histoire d'Antibes : temps et espaces de l'homme en société, analyses et modèles spatiaux en archéologie, Ed. Jean-François Berger, Frédérique Bertoncello, Frank Braemer, Gourguen Davtian and Michiel Gazenbeek, 2004.

Forte M., Pescarin S., Pietroni E., Dell'Unto N., *An integrated approach to archaeology: from the fieldwork to virtual reality systems,* in Proceedings of CAA2004, Prato Apr.04,

Gamma, Helm, Johnson, and Vlissides. *Design Patterns: Elements of Reusable Object-Oriented Software.* Addison-Wesley, 1994

Liguori M.C., Pescarin S., Diamanti T., Guidazzoli A., Felicori M., *3D Temporal Landscape: a new medium to access and communicate archaeological and historical contents*, in Proceedings of CAA2004, Prato Apr.04

Lindstrom P. and Pascucci V. *Visualization of large terrains made easy*. IEEE Visualization 2001, 2001.

Renfrew C., Zubrow E. (eds.) 1994, *The Ancient Mind: elements of cognitive archaeology*, Cambridge UP

Rottger S., HeidrichW., Slusallek P., and Seidel H. *Real-time generation of continuous levels of detail for height fields*. Università di Norimberga, 2004.

Woo M., Neider J., Davis T., and Shreiner D. *OpenGL Programming Guide: The Official Guide to Learning OpenGL, Version 1.2 3rd ed.* Addison-Wesley, 1999.

Appia Project web site: http://www.appia.itabc.cnr.it

OpenSceneGraph web site: http://www.openscenegraph.org

Virtual Terrain Project website: http://www.vterrain.org

6. ACKNOWLEDGEMENTS

Partner of the Appia Antica Project: CNR-ITABC, Istituto per le Tecnologie Applicate ai Beni Culturali (Maurizio Forte, Paolo Salonia coordinators); Archaeological Superintendence of Roma municipality (coord. Paolo Grassi, Antonio Mucci, Luca Sasso D'Elia) ; Italian Archaeological Superintendence (Dott.sa Paris); CINECA Visit Lab: Cooperation on OpenSource tools for the reconstruction and visualisation of archaeological landscape.
Partners of the Certosa Project: Bologna municipality (M. Felicori, C. Borgatti, M.C. Liguori, R. Martorelli, M.Bacchini, N.S. Onofri, M. Lodi); CINECA (A. Guidazzoli, A. Mauri, F. Delliponti, L. Calori, T. Diamanti); CNR ITABC (S. Pescarin); HERA (M.Gaeta, R. Zanetti); ISTITUTO PARRI: (L . Alessandrini, L. Cigognetti, C. Crupi).
A particular thank to Silvano Imboden (CINECA) who developed the ActiveX plug-in for Internet Explorer