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Interactive Landscapes Reconstruction: a Web 2D and 3D OpenSource solution

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Abstract

The paper will focus on a novel desktop and web-based VR system based on OpenSource tools. The system lets a user to navigate in large territories, in real time and through the Web. It allows a dynamical interaction with geographical data and 3d models, adding points of view or personal paths, activating or deactivating thematic layers that can be viewed directly on the terrain. In this way it's quite easy to share data and information (at research level) and also to better understand the landscape (at user level).
The system realised is based on two open projects: OpenSceneGraph library and Virtual Terrain Project. They were used in combination, modifying or producing new parts of their code and adding plug-ins, in order to create a tool useful to reconstruct complex landscapes, starting from GIS data (DEM, GeoImages and vector data). With these data it's possible to build a three-dimensional terrain through a tool, OSGdem, that generates paged and hierarchical terrain databases. OSG was integrated with VTP, whose original code was modified so to import even different terrain database formats (flt, txp, ive). Inside VT Enviro it's possible to modify dynamically, three-dimensionally and in real time the landscape, using external libraries of 3d models, vegetation, animals, etc. and inserting them even directly on the scene, at a certain geographical co-ordinate. We then implemented OSG potentialities of .ive files publication over the Web, allowing VT Enviro to export the modified landscape. An ActiveX plug-in was built for Internet Explorer to load the paged landscape from a Web server in the browser.

Categories and Subject Descriptors: Novel Internet-based CH Applications

1. Introduction. Problems and state of the art between research and dissemination

Recently we are observing a development in the fields of methodologies applied to Cultural Heritage, partially pushed by the evolution of technology, partially by EU or national economical founding policy and by an increasing interest oriented toward communication and dissemination. There is a growing interest, indeed, towards problems connected to the management of huge amount of spatial data, different for typology and scale, to the diffusion and to the digital sharing of cultural information. Either the 5th and 6th Framework Program of the European Community either UNESCO are clearly addressing cultural institutions to realize, as prior activities, accurate digital maps of cultural and environmental resources of the planet and, secondly, to build networks and to share and communicate information. [www.unesco.org, fp6.cordis.lu/fp6]
In comparison with the technological gap and delay that Cultural Heritage field has always suffered, we have to point out an important step forward. The recent development of mapping techniques (due to the diffusion of Differential GPS, Scanner Laser etc.) and of data post-processing, increasingly more accurate, is proposing, to the scientific community *in primis*, new kind of problems to be solved: how to manage Giga or Peta of data? How to exchange and integrate them with other kind of information? How to communicate and distribute them? How to reduce data post-processing time ? [FPP*04]
We think that there is also a risk hidden behind this. Such an amount of digital data acquired for each archaeological complex, architectonic monument, artistic piece of art, could easily become a series of immense monograph, not integrated with any other source of information, visible and available just locally and for restrict scientific communities. Dissemination and communication, that should be one of the fundamental tasks for those who works in the field of Cultural Heritage, would be partially neglected.
DVRa systems (Desktop Virtual Reality in archaeology) have indicated, in the last 5 years, their potentialities [For95], [For96], [VSMM01], [VSMM02]. These systems indeed allow to treat scientific data in a spatial and three-dimensional way, to connect and integrate them with other kind of multimedia information and also to communicate, in a simple and direct way, even complex contents to the community. With "virtual reality" in fact we intend a digital immersive system of interaction, able to explore all the relations between spatial information, increasing factors of perception and therefore increasing the knowledge of the landscape. In fact, a reconstruction process starts from the interaction of all the data from the beginning of the investigation until the final interpretation. Step by step virtual reality can take all the phases of processing and visualization with the faculty to create maps of the environment in diachronic way, overlapping in 3D different sources of data [For00].
Unfortunately the story even of these applications rarely remained open and available for public users [FPR02], [www.fhw.gr/cosmos/en/vr/].
Even for this reason the two teams of CNR ITABC Virtual Heritage Lab [www.itabc.cnr.it/VHLab] and CINECA Visit Lab [www.cineca.it] decided to dedicate part of their research activities, trying to develop different kind of VR

applications, not only dedicated to home computer or to single installations inside museums (i.e. Aksum project [FW02], Scrovegni Chapel Virtual Museum [FPR02]) or to more collective spaces such as virtual theatres or caves, but also to a much more diffuse media such as Internet.

1.1 Open-Source: a choice for the future of Cultural Heritage

A digital research protocol has been proposed and followed by the two interdisciplinary teams, in order to give more freedom as possible during data acquisition and post-processing phases, keeping integration and spatial - temporal overlaying between information. The complete process, that starts with mapping activities in the field and leads to Web VR applications, passes through different phases [FP04]. The primary goal is to keep a continuous connection between data, based on their spatial components, independently if they are texts, images, models, terrain databases or other multimedia contents (Figure 1, Table 1). The possibility moreover to manage different digital formats didn't impose restrictions, giving the necessary flexibility and extensibility even for future developments.

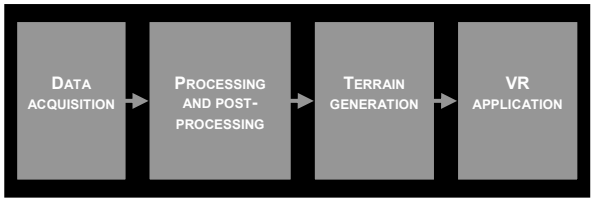

Figure 1. *The process from data acquisition to VR application.*

We tried also to integrate and to use Open-Source software, where it was possible, modifying it when necessary. The use of *open* tools, projects and protocols was a choice made for technical reasons but also for a more socio-economic perspective.

From a technical point of view, we were interested in using some already available capabilities of a particular Open-Source project (OpenSceneGraph) to publish three-dimensional territorial data, for real-time navigation, over the Web.

From a socio-economical perspective, on the other side, we were interested in building an OpenSource project for Cultural Heritage, experiencing advantages and difficulties also from the "user" (archaeologists, historians, etc.) point of view. We found many possible advantages for the specific field of Cultural Heritage, such as: low cost of the solutions, sustainability of the projects, push towards resources sharing, simplicity in the re-use of data already processed and in the integration of known and well established methodologies, valorisation of 'human' investments more then on 'technology'. Furthermore the interest on Internet allowed, through the two Open-Source projects followed, to participate to their community, acquiring the tools already available, managing different protocols, using the code provided to create applications, re-using the same code in order to improve and extend it and, at the end, returning it to the community

Table 1 represents schematically the digital protocol. As explained above, it is used as general guideline to create a system for the reconstruction of the archaeological landscape, in a process that has to take into account the different phases of digital processing, helping to explore the relations between *data processing* and *data representation*, between *observed landscape* and *reconstructed landscape* [FPP04].

The system realised is based on two open projects: OpenSceneGraph library [www.openscenegraph.org] and Virtual Terrain Project [www.vterrain.org]. They were used in combination, modifying partially the code and adding plug-ins, in order to create tools useful to reconstruct complex landscapes, starting from GIS data.

Source data, acquired for example on the field with topographic surveys (laser total station, differential GPS) or architectonic and photogrammetric surveys (laser scanner, laser total station) are used to build a *GIS project* that is at

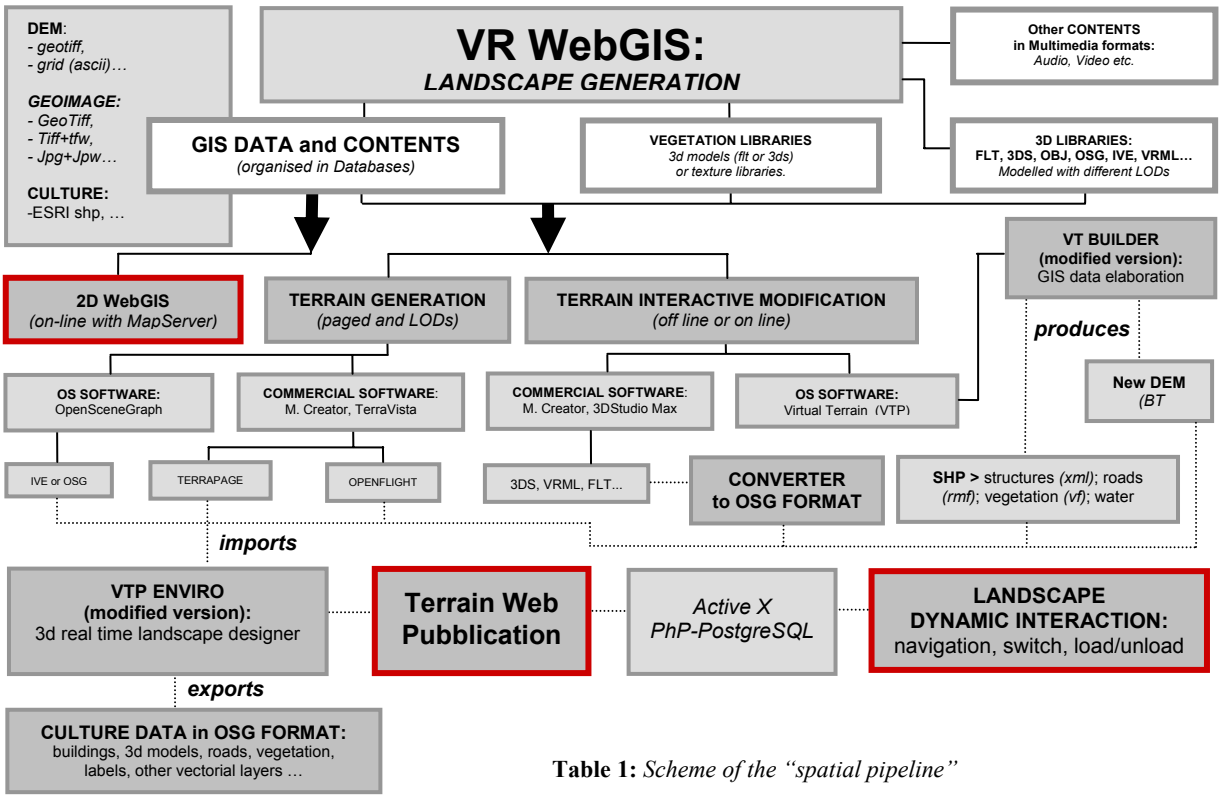

Table 1: *Scheme of the "spatial pipeline"*

the bottom of the remaining phases. GIS data are used and published in a *WebGIS*.
Digital Elevation Models (DEM) and aerial or satellite imagery are then processed in order to produce a 3D territorial base, paged and at different levels of detail (*terrain generation*).
The landscape is then modified (*terrain interactive modification*), keeping the terrain database, but adding, deleting or moving "culture data" (human or natural characteristics of the landscape such as streets, buildings, vegetations, and so on) (figure 3).
After this phase, data are converted and saved in a format useful for Internet and published.
A good case-study to test the complete system developed was the Esaro-Valley project and its web-site.

2. Esaro Cultural District: a complete test case

The Esaro Valley, in southern Italy (Cosenza province), is a perfect paradigm of what it's possible to find in many other provinces in Italy. It is a stratification of many historical events, archaeological sites, cultural and natural places. It has been crossed by different populations: Greeks, Romans, Normans, Albanians. Most of them left remains in many places (castles, villages, necropolis, villas, etc.) or in the traditions that are still alive in the region. There are also characteristics, still visible, that make the territory quite peculiar for a visitor: the community of Albanians, for example, that arrived in Italy after 1468 (27 arbëresh communities are located in the province of Cosenza) is still present, keeping alive their traditions.
But this area is almost unknown outside its limited territory.
The goal of the project was therefore to try to increase the value of the territory with different actions, mainly unifying all the municipalities of the territory under the same "cultural district" , keeping, at the same time, their integrity and singularity, activating a complex process of dialogue inside the territory, letting the municipalities themselves to be part of the process of "opening", letting them telling their stories, exchanging their experience with scholars, archaeologists and historians of the University of Calabria .
For this reason, thanks to this project, a visiting and tourist centre was created in the area (Multiservice Centre "Sistema Cultura - Valle dell'Esaro"in the municipality of Malvito), itineraries inside the territory were created, guides were published and distributed locally and a innovative web-site was realised.
The "cultural district" tries to build a bridge among local communities, researchers, public administrations and tourists. Tourism in fact can be an important component in the development itself of the Valley, together with culture. The itineraries realised in the area try to give the possibility to the visitor to discover the Valley, but they were also a good opportunity for local communities to better know themselves, recognising their originalities, rethinking the perception of their territory, based on the knowledge of the past and in the perspective of the future.
The "cultural district" tries to help a territory to show itself in its complexity as it was, it is and it could be. And Internet was a perfect way to realise it.
The web site was thought as fundamental part of the project. In fact it was one of the best way to let the visitors to start knowing the place, without removing their interest for a real visit.
The project of the web site was also thought and realised in order to become:

- a guide and a starting point for tourists
- an updatable tool useful for the local communities, even thanks to the sustainability offered by the Open-Source software used.
- a scientific base for researchers and scholars.

The Esaro Cultural District project has been also a perfect case-study to try to integrate as much as possible, 2d and 3d metaphors. For this reason we planned two main sections, *Interactive Map* and *Virtual Reality*, from which contents could be reached.

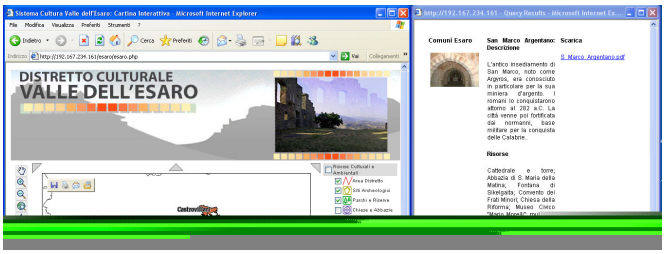

Figure 2: *WebGIS of the Esaro Valley. On the left the Map Server Chamaleon interface. On the right the result of a query.*

3. Web 2D and 3D VR

3.1. WebGIS

In the WebGIS section an interactive map based on GIS data was implemented. It was developed with two Open-Source applications.
The management of vector data, thematic layers, geo-imagery and altimetry was possible thanks to the use of MapServer WebGIS engine. According to the queries made by a user, different views of the published data are generated, as images and informative pop-ups.
MapServer is an OpenSource CGI-bin development environment for constructing spatially enabled Internet web applications, connectable to any web server [mapserver.gis.umn.edu].
In the case of the Esaro Valley web-site, the tested configuration is MapServer and httpd Apache.
The configuration of MapServer is done through the creation of a correct setting of the MAP file that defines:

- Dimension of the display window and extent of the visible region
- definition of the defined metric unit and the zoom scale
- definition of the legend and of the reference map
- definition of the available vector layers (shape) and of the options of visualisation such as outline colour, transparency, metadata, projection, query parameters for specific layers, and so on.
- setting up of the subsidiary information of the layer, such as text labels, font, shading and symbols
- managements of the query for the data contained in the "DataBase File (.dbf)"associated to the

vector layer (shape) and creation of window dedicated to the presentation of the results
- switching among different layers, according to the viewing scale of the interactive map

The creation of the user interface (figure 2) was possibile thanks to the use of a library included in MapTools packet: Chamaleon [chameleon.maptools.org].
Chameleon is a distributed, highly configurable, environment for developing Web Mapping applications. It is built on MapServer as the core mapping engine and works with all MapServer supported data formats through his regular MAP file. It also works well with OpenGIS Consortium standards for Web Mapping Services (WMS) and WMT Viewer Contexts through MapServer's support for these standards. Chameleon technology was developed as the Configurable Web Mapping Client Component (CWC2) for Canada's GeoConnections Access Program and was developed through the libraries MapScript using mainly PHP scripting languages [www.php.it], JavaScript and XML.
The creation of the application for Esaro Valley is based on the generation of an *init* page in PHP that recalls the different settings of the Chamaleon interface and a series of templates for the generation of the pages.
In detail, three different templates are requested:
- to generate the interface,
- to create the skin applied to the buttons and to the graphic elements of the generated pages
- to generate checkboxes for loadable layers.

The creation of the checkboxes is done through an XML file processed run-time by a XML renderer (widget CWC2) that takes care also of controlling the MapServer engine.
To visualise the results of the query, the widget CWC2 Query, contained in the release version, was extended. Each query produced by MapServer was formatted in order to display relevant information of the layers, associating to them images and links, for more detailed information (in PDF format).
In specific the following tools were implemented (figure 2):
- Zoom and Pan functions on the interactive map
- Measure functions: it allow to calculate the distance of a series of points, useful in the case of the itineraries for example
- Point-Query functions referred to the active layers
- Switching functionalities among different thematic or cartographic layers

The project of the WebGIS was done also in accordance to the requests received by the public administration, and oriented to simplicity for file – updating.
The same GIS data used for WebGIS section were processed to create the 3d dynamic and interactive section

3.2. Web 3D VR GIS

In order to give to the user the possibility to explore more interactively the landscape, letting him to discover it in three dimensions, a 3D VR section has been created.
The technical goals of this section were to assemble and demonstrate the feasibility of a complete workflow based on OpenSource projects for the construction of GIS based 3D interactive landscape and models, accessible to users through Web interfaces.
The first attempts we have done date back to 2003 -2004 and were presented during the workshop "Open-Source and Free-Ware for Archaeology" during CAA2004.
At the beginning we tried to analysed and compare other commercial tools/projects already available. VRML or GeoVRML apart, we found, up to now, four main comparable products:

1) Skyline [www.skylinesoft.com] is a commercial packet, with lower network bandwidth, lower hardware requirements; it's quite good on urban area, for texturing of buildings, but it is a close system, quite expensive, with no available interactive building tools and no culture data.
2) Flying over Elba Island [www.rete.toscana.it/sett/pta/cartografia_sit/sit/elba3d/it/start.htm] is another commercial, robust plug-in, based on Macromedia shockwave; it offers lower bandwidth, but no culture nor no available building tools.
3) In the last months (May 2005) NASA has developed WorldWind [worldwind.arc.nasa.gov]: it's an OpenSource product, based on DirectX (for windows users), with a better bandwidth and navigation interface, good scalability, a strong GIS support thrugh open standards, (WMS), but no culture data nor published building tool.
4) The last application is GoogleEarth [earth.google.com]: biggest database, best network usage, with a very nice interface for large scale navigation, routing, map visualization, waypoints, searching; it seems to be closed and without building tools. Although we don't have information about costs, it is surely the best example of Web 3D VR.

The Open-Source project we start to develop in 2004 has the primary goal to be a simple system:
- for non-programmers users,
- for large territories generation, based on GIS data,
- for cultural landscape reconstruction, through interactive 3d operations of adding, moving and deleting culture data (either 3d models either vector layers).
- For landscapes publication over the Web

Therefore the system should have been scalable to support virtually unlimited area/resolution.
Time response should be rapid: a rough overview of the scene should appear quickly, navigation should be kept fluid, even on non high end-platform.
Higher details should be downloaded seamless by following the user interest points.
The system should also support a variety of primitives, not only textured Digital Elevation Modelled terrains (good for wide scale overview) but also vegetation, buildings and other high detailed models.
Furthermore, the landscape-building-tool should have allowed both a "batch operation mode" for the construction of wide area models from GIS data as well as "interactive editing mode" to be used for refining the landscape at a much smaller scale adding building models, vegetation, roads, rivers and so on, with a user-friendly, interactive interface, suitable for the creative work of archaeologists architects and modellers.
This goals and constraints have guided the selection of the Open Source tools that has been used and integrated within the project.
As foundation library for the rendering tasks, has been selected the OpenSceneGraph project, a state of the art general purpose SceneGraph library based on OpenGL [www.openscenegraph.org].
This library, that is constantly expanding his user group base, is particularly well suited for the project because it already support an efficient multithread PagedLOD handling within the core and already implements an application to build hierarchies of PagedLOD nodes of terrain tiles out of GIS raster and elevation data.
OpenSceneGraph is also able to load many of the file formats produced by the main modelling software used by the teams, for real time scene modelling (such as Multigen Creator, Max, Maya and Blender).

OpenSceneGraph supports also the TerraPage paged file format (*.txp) produced by Terrex TerraVista [www.terrex.com], one of the main commercial packages for paged-terrain generation. It is also cross platform (Unix/Linux, Windows, Mac), GUI neutral and highly extensible.
OpenSceneGraph has also been used as base library for the VirtualTerrainProject [VTP: www.vterrain.org] that provides tools, such as VTBuilder and Enviro. Enviro, in specific, implements a user friendly interface to interactively place plants, buildings (even directly generated from *.shp/*.dbf files), roads, rivers, 3d models directly onto the terrain model, in 3d **(figure 3)**.
The main limitation of the VTP suit (that comprises also a simple GIS-based culture generation with VTBuilder) is that it does not support paged terrain hierarchies and so can not handle large terrain databases.
For this reason one of the first activities was to modify the code in order to enhance Enviro by adding tile terrain support, enabling, at the same time, culture data (plants, building and models, up to now) to be attached to the tiling hierarchy.
By integrating plants, buildings and models into the tile database schema, we were able to add greater detail to scenes, while keeping satisfactory frame rate and reducing network download time.

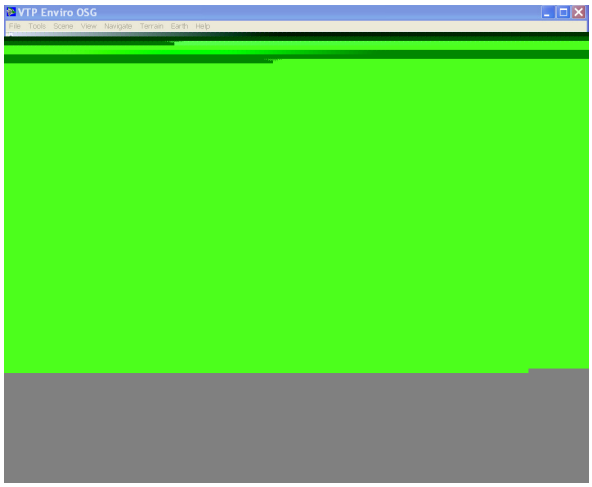

Figure 3: *Interactive reconstruction of the archaeological landscape of Appia Antica Park in Rome (Italy) with the modified version of VTP Enviro, which allows even *.flt/*.txp/*.osg terrain databases to be loaded.*

For web based presentation, we used an ActiveX component that integrates OpenSceneGraph viewer functions that lets remote interactive navigation of the tiled terrain database. The component uses an OSG feature, which allows network downloading of models, while the network bandwidth consumption is some how reduced by using compression schemas on texture data.
The ActiveX component integrates within Internet Explorer, thus letting standard web interface integration.
Some functionalities have been developed specifically for the project, in order to allow the user:

- to switch between predefined viewpoints,
- to selectively activate information layers (roads, rivers, interest points, labels) and
- to switch between different landscape models (figure 4).

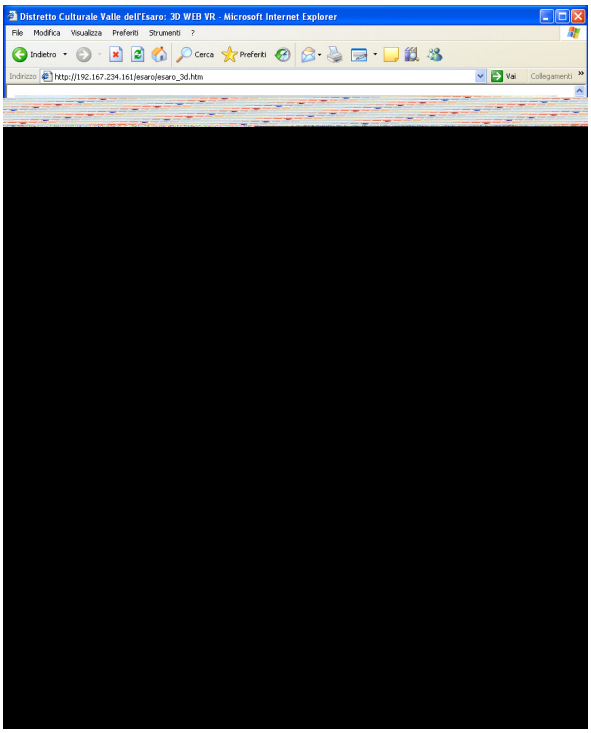

Figure 4: *Esaro-Valley VR WebGIS on Internet Explorer. Interaction with landscape*

These additional data such as viewpoints and components are kept within a database so to allow the authorized user to add new data such as viewpoints, labels, icons etc. (table 1)
This will also allow site administrators to keep the data updated.
Our data workflow follows this schema (see also table 1): GIS raster and elevation data are processed through *osgdem* so to obtain a tiled and paged terrain database. In the meanwhile GIS vector data are imported and elaborated with VtBuilder, producing XML 2d data. These 2d data, together with the tiled terrain, are then modified inside VT Enviro, letting the user to modify the landscape (adding, deleting, moving objects, etc), creating, at the end of the process, a culture-enhanced Tiled terrain Database. A Database of additional information is connected with the web presentation.

4. Conclusions and future developments

In the next future we would like to work on the integration between Web 3D VR and WebGIS, in order to allow a complete customization and further interactions, letting the user to define its own path, for instance, to record his visited places, to add photos, to add viewpoints, and so on.
Another important enhancement will be directed to the network performance improvement, by more aggressive compression, using jpeg 2000 formats. We would like to get to a better realism on ground scene, trying to integrate effects like shaders, bump-mapping and so on. Even the navigation interface need some improvements for data selection.
The system could support also virtual communities.
We think indeed that it would be very interesting to use the system for different purposes, such as to exchange information or specialised knowledge; to share resource; to exchange and propose new and different interpretation on objects (models, landscapes, sites, and so on); to share

collective memories; to build communities based on cultural narrative, stressing the importance of social aspects, next to exclusive and elitarial cultural aspects; public involvement in the process of new knowledge creation; to facilitate a shared collective participation to cultural politics through a democratic space, such as that offered by Internet, where each citizen could participate as expert on some subjects or as novice on some other. A web interactive system could easily promote even an open participation, as scientists community but also as citizens community, to the creation of digital archives, collections or virtual museum.

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The website and its interface was developed by CNR ITABC, VHLab (www.itabc.cnr.it/VHLab): M. Forte (scientific director), S. Pescarin, C. Camporesi (editing and development WebGIS and VR), V. Trabassi (graphic); CINECA – Visit Lab, Bologna: L. Calori and S. Imboden (Active X plug-in)

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Open Geo-Spatial consortium: *www.opengeospatial.org*

MapServer web site: http://*mapserver.gis.umn.edu*

Chameleon web site: http://*chameleon.maptools.org*

Esaro Project website: *www.esarodistrettoculturale.it or http://192.167.234.161/esaro/*

OpenSceneGraph website: *www.openscenegraph.org*

Virtual Terrain Project website: *www.vterrain.org*