Virtual Rome

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Abstract

Virtual Rome is a project started and carried on by the Virtual Heritage Lab of ITABC-CNR (Institute of Technologies Applied to Cultural Heritage of the Italian National Research Council), in collaboration with CINECA. The Project's goal is to reconstruct the archaeological and past (potential) landscape of Rome in the 2nd century AD and to build an on-line development and visualization platform based on Open Source software, which is a double-sided tool, consisting of a back-end (VR webLAB) and a front-end (VR webGIS) section. This is a collaborative system developed to manage the data necessary to reconstruct a 3D interactive environment in real time.

Keywords: *3D, web GIS, virtual landscape reconstruction*

1 INTRODUCTION

Virtual Rome is a project directed by the VHLab, Institute of Technologies Applied to Cultural Heritage of the National Research Council (ITABC CNR), in collaboration with super computing center CINECA, Seat Pagine Gialle and other local partners (the Chamber of Commerce of Rome and the Superintendency of Rome). The idea, born in 2006, has established the goal of creating a Virtual Reality application based on a Geographic Information System (GIS), which is interactive and navigable on-line.

Figure 1. *3D model of the Forum Augusti in Virtual Rome.*

As the name suggests, the main purpose is to reconstruct the landscape of Rome in modern and ancient times (fig. 1), through a web-based Virtual Reality application based on Open Source libraries, remote sensing, geographical data and three-dimensional models. This application is able to manage information and make it usable in real time for technical information in a scientific field, while being appealing and accessible to the general audience of the network.

In practice, the aim of the project is the development and implementation of a visualization platform tool, consisting of a back-end (VR webLAB) and a front-end (VR webGIS).

2 PROJECT REQUIREMENTS

The development work of this application has followed a series of steps carried out simultaneously by the various working groups: first, the development of the software OSG4WEB plug-in for Internet Explorer and Mozilla Firefox; next, the development of 2D and 3D contents regarding the archaeology, architecture, and environment of Rome in the second and in the twenty-first centuries AD; and finally, the development of several utilities for 3D content publication over the web, as paged 3D terrains, vegetation, optimized 3D models, multimedia hyperlinks, a 3D Internet site on Roman landscape, and so on.

The Virtual Rome project had certain requirements, such as support for paged geospatial datasets, coordinate and projections handling, large terrain management, 3D model integration, support for vegetation and other natural elements, vector layers integration, online 3D data publication, web-browser embedded interaction, and fly- and walk-through navigation tools.
To achieve these purposes and allow the navigation inside the three dimensional space (actual and ancient; see fig. 2), a specific plug-in was developed and built, embedded in the most popular web browsers (Internet Explorer, Mozilla Firefox and now in testing on Linux).

The framework that best matched these needs was OpenSceneGraph,[1] especially for the efficient and clean clean paging support for hierarchical terrain databases and as well as a batch application (*osgdem*) for generating the final structure from GIS data. The open source software is based on the OpenSceneGraph library and has been published under the GPL license, while contents are available under the Creative Commons licence.

Figure 2. *Present and ancient landscape of the Rome area.*

3 OSG4WEB PLUGIN

The 3D rendering application is based on previous work of the team. A web browser plug-in, able to display and navigate real 3D environments inside the browser, was built (on top of the 3D graphic library OpenScene-Graph) and released in 2004. A new plug-in, *OSG4Web,* was developed for a more interactive 3D experience. It is the main rendering engine, composed of a Shell component and a Rendering Core. The Shell component is responsible for downloading and integrating the rendering engine (the core) within the web browser and the web page. It is also the communication channel between the user (through JavaScript/Ajax and browser messaging system) with the rendering core. The core component is the real 3D graphic engine; the main core developed for this project has different functionalities:

- Paged terrain loading
- 3D exploration of the hierarchical scene (a master file; the first to be loaded is generated by the back-end section)
- Terrain switching
- Vector or other model loading
- Viewpoints and paths loading
- Object picking and loading of external multimedia content
- Environment integration (fog, sky, etc.)
- Tooltip display

[1]www.openscenegraph.org.

4 LANDSCAPE RECONSTRUCTION

The entire project is based on collaborative research carried out by specialists involved in the reconstruction of landscapes, both modern and ancient. This type of reconstruction requires different skills and involves several fields of expertise, from geology and archaeology through architecture to cognitive communication.

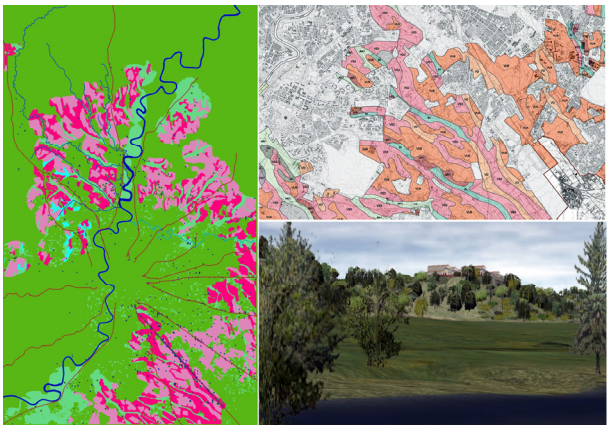

Figure 3. *Virtual ecosystem.*

The actual Virtual Rome terrain was created by the hi-resolution Digital Elevation Models and aerial photographs provided by Seat Yellow Pages-Nuova Telespazio (20 cm resolution). The 2nd century terrain was created by means of a very careful reconstruction of the ancient environment and monuments. Interdisciplinary research was carried out in cooperation with geologists, paleo-botanists, and archaeologists from distinguished institutions and universities. Various sources were fundamental in reaching this goal, such as the acquisition of the dataset of 20 cm resolution aerial photos of Rome, DEM at 10 m of resolution; the archaeological maps of the zone or the previous survey and acquisition of specific areas; the soil map of Rome; and the geological and vegetation maps.

The first question in the reconstruction of a landscape should be about the original aspect of the environment, what were the characteristics of a monument or archaeological site, what were the relations between humans and nature, and so on.

For this reason, a scientifically explicit theoretical approach for the reconstruction of the archaeological and ancient landscapes was followed. This was accomplished through the use of GIS tools and applications aimed at the reconstruction of virtual ecosystems (fig. 3). The need to integrate different sources has posed various problems about methodology, archaeology, and computing: the dimensions of the original geo-spatial dataset; the various data (vectors representing different information, images, three-

dimensional models, plants, multimedia, and metadata information) or different post-processing pipelines regarding diverse ontologies; and different scales and resolutions of the models to be handled.

Through the integration of these different data, it has been possible to demonstrate an explicit theoretical methodology for the realization of reliable ancient landscape reconstruction through the study of ancient sources and the analysis of aerial photographs and/or modern maps. The working chain for such a project starts with the GIS elaboration of the various data collected (maps, terrain, vectors), and continues with the creation of 3D ecosystems useful to the reconstruction of our virtual ancient landscape.

Figure 4. *3D model of the Milvian bridge.*

For ancient buildings (fig. 4) and man-made products, we have roughly adopted the following workflow. After a survey of the monuments with different acquisition techniques (for example, with laser scanner, photo-modeling, or photogrammetry), the data are post-processed in the laboratory to achieve a sound digital reconstruction of the current state of the remains. Afterwards, following strict scientific methods based on the remains and other information, a reconstruction hypothesis is formulated as a highly detailed, high quality 3D model. These high res models are then reduced/optimized for interactive web deployment. This procedure is primarily a semi-automatic splitting of the original models into sub-parts and extraction of low levels of detail. This process is vital for allowing decent user interaction with the huge amount of data.

5 FRONT-END

Through the VR webLAB, a front-end 3D interactive environment is created (*VR webGIS*) for on-line exploration of large archaeological landscapes. This allows users to explore the scene, connecting the GIS functionality to the Virtual Reality capabilities, activating layers, acquiring information, etc. The system is web-based, geo-spatial and open source. Currently, it allows users to navigate and interact by switching between two different terrain models: the archaeological actual landscape of the twenty-first century and that of the early Imperial period of Rome. In particular, the area covered by the project includes the general reconstruction of the landscape of Rome (based on a explicit theoretical method of reconstruction) with some deeper zones, where it is possible to visualize the buildings and structures relative to the second century A.D. and walk inside them. These zones are the Via Flaminia in the north, the Via Appia in the south, and the Roman Forum area, in the center of the city.

6 EXPLORING VIRTUAL ROME

Navigation in virtual environments has a direct impact on user interaction and a great influence on the quality and level of content comprehension. User disorientation can arise from poor usability of the navigation interface, poor feedback with simulated objects, and lack of navigation cues. Overall immersion can often be unsatisfying and does not come easily to huge terrain databases, such as in the case of Virtual Rome.

Within interactive web-based virtual reality applications the user is also confined to conventional input peripherals: mouse and keyboard are two-dimensional controllers, while 3D navigation in a virtual world requires a satisfying viewpoint manipulation with six degrees of freedom. Exploring the complex virtual 3D scene and the ancient landscape of Virtual Rome has a huge impact on user and content interaction: the open source OpenSceneGraph framework itself provides a set of manipulator tools, mainly used to manipulate the user camera.

One of our main goals was to provide a powerful navigation tool for a rich and pleasant exploration of the virtual environment, offering both direct experience with the content and ease of use. For these reasons, we developed a navigation system that is suitable for large terrain models, user-friendly, and portable into other environments and projects. This system, conceived for 3D exploration of the Virtual Rome landscape, is called *ViRo*. It provides the user with a simple and usable tool to explore the virtual world using aided navigation modules, configurable according to user needs, simulated environment needs, and system capabilities. Using this tool, users can fly up, onto the twenty-first century and the second century landscape, visiting, querying its archaeological sites, and walking inside its monuments (fig. 5).

An informative overlay is provided both in Front-End (webGIS) and Back-End (webLAB) to display current orientation, height, speed, position, and other useful data for immediate feedback. Another important aspect within the web-based applications is the data transfer feedback over the internet: users are given complete feedback of the download progress of 3D *multi-resolution* monuments and terrain tiles during the session. To reach the final goal of aided navigation in such a complex environment, several modules have been developed to gently correct movements or adjust peripheral sensibility in certain situations such as

proximity with objects or surfaces. Advanced collision detection and obstacle avoidance algorithms, joined with different exploration modes, are provided together with the walk mode, using basic physical effects such as gravity and surface adaptation.

Figure 5. *Walking inside the 3D model of the ancient Villa of Livia.*

The final goal is to enhance the landscape and environment interpretation and improve the user experience and the overall quality of the exploration.

7 BACK-END

Another goal of the project, currently under development, is especially innovative: that is the further development of the VR application into a 3D interactive, editable, on-line laboratory on ancient landscape, which will be interactively updatable even with new and different projects and models developed by other institutions or partners. In fact, the project is moving forward, with the final goal of creating a web-based 3D cooperative interactive environment (fig. 6). The back-end collaborative system (VR webLAB) was developed in order to enable the integration of the reconstructed 3D terrain dataset, high resolution 3D models, vectors, vegetation information, and metadata. In this way, the Virtual Rome project is developing an on-line cooperative environment for interactive reconstruction involving different professionals and specialists in the same process.

Landscape reconstruction requires a *multidisciplinary* and an *interactive* approach. It involves disciplines such as archaeology, history, anthropology, architecture, geology, geomorphology, paleobotany, geoarchaeology, climatology, lithology, agricultural studies, and so on. But all these disciplines need to continuously maintain a reference with spatial data and temporal dimension. Therefore, researchers need a place to interactively share their knowledge and research, coordinating their work with the common goal of reaching a reliable and scientific result. For this reason, a web interface, developed as a Content Management System, was created in order to create, edit, and modify the 3D scene and the web pages dynamically.

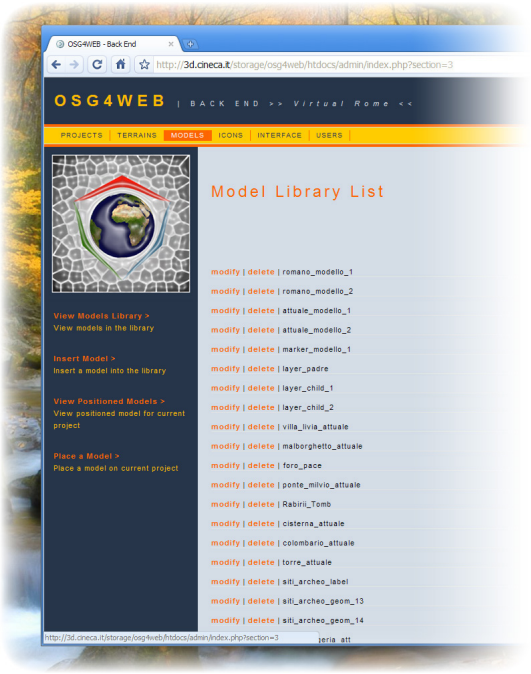

Figure 6. *Back-end in the web browser.*

The back-end section, with a MySQL database behind it, is structured in Projects, which are web publishing projects. Each Project can have different terrains, points of view, models, and interfaces. While all the different resources can be stored in the Model and Terrain libraries, the Interface section of the back-end provides the capability to control the final Virtual Reality application, deciding how many landscapes should be available and switchable, how many models should be attached to a certain terrain, how many icons should be visible with a specific function. The Model section allows us to add a 3D object in a specific position and to decide the link a user can activate, clicking on it. Moreover, through the back-end interface, it is also possible to dynamically create different viewpoints and paths, just storing the camera position while exploring the landscape, and to manage points of view and paths, customizing every application feature and building any virtual world and historical landscape.

8 CONCLUSIONS

We (and the Italian E-content Award committee) believe the project has reached the innovative goal of deploying on the web a wide area, multi-time, multi-scale archaeological reconstruction. The system has demonstrated the feasibility of in-browser web deployment of rich and vast content. Since it is almost entirely based on Open Source components, the project can better adapt to technological changes by easily replacing other open source components (see recent Google O3D API). Our work flow can also evolve into a powerful and user-friendly tool, which can be useful as an *open laboratory* for scholars and professionals who can interact on the web, sharing data, building

common digital libraries (architectures, vegetation, terrain textures, materials, etc.) and testing hypothesis on past landscape through simulation sessions. At the same time it may work as an innovative dissemination and teaching instrument.

To achieve this goal, the project has the following development priorities:

- Integrating a visual and direct way to add 3D models into the 3D landscape through the back-end section to enhance final ease-of-use;
- Adding a chat section for the enabled users while reconstructing the landscape;
- Integrating vegetation
- Adding artificial life;
- Integrating procedural techniques for reconstructions.

The application is currently available at www. virtualrome.net.

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