3D GEOEXPLORATION OF THE PREALPI GIULIE NATURE PARK (ITALY)

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KEY WORDS: GIS, Open Source, DEM, 3D exploration, surface modelling, landscape, navigation, Web dissemination.

ABSTRACT:

The aim of this research is focused on the development of an Open Source platform that would provide a 3D interactive and flexible geo-visualization of spatial data coming from geographic information system (GIS). The application regards the cross-border spatial databases connecting the Prealpi Giulie Nature Park (Italy) and the Triglav National Park (Slovenia). Efficient methods were developed for data processing and data diffusion in a transnational Geo-portal by MapServer.
To augment the realism of the product, from the bi-dimensional representation to the three-dimensional one, we adopted the Virtual GIS solution. The Virtual Reality in the GIS allows the visual data access in a 3D context and some real time performances. So in this project we had some opportunities to implements different scenarios improving the understanding of the landscape and allowing a virtual walk inside the park areas. This needs appropriated visual-display techniques and data-mining methods. We used Virtual Terrain Project (VTP), an Open Source software, suitable to construct any part of the real world in interactive 3D digital form. VTP supports a set of software tools: VTBuilder, which elaborates geo-referenced data to represent them in two dimension and Enviro, an interactive runtime environment, which creates virtual three-dimensional scenarios and allows the 3D navigation.
Every data management is performed by internal routine but it is possible to personalize them for specific purposes as in agreement with the Open Source code.
The management of the 3D data lets to work at different levels of detail. The algorithm LoD (Level of Detail) performs detailed analysis on the data and is useful to simplify the displayed procedures applied both to the textures and to the meshes of the ground. Fluidity of movement is a fundamental requisite for the Net.
The field of employment is devoted to virtual tourism, travel planning, land use, urban planning, civil engineering and disaster management for the analysis and for the assessment of environmental impact. The obtained 3D flight over the Prealpi Giulie Mountains is very suggestive and, not only but moreover, it can be useful for the knowledge of this environment and to solve any related problems.

1. INTRODUCTION

In the past cartography played an important role in the exploration of the world. Recently a new phase in mapping has started. The cartographic visualization process, that means “to make visible”, is considered to be the translation or conversion of geospatial data from a database into map products. The progress in other disciplines has linked the word *visualization* to modern computer technology to facilitate the process “to make visible”. Recent trends in cartography have to do with the impact of visualization and the need of interactivity and dynamicity as well as the widespread use of geographical information systems. The goal requires a synergetic convergence of the disciplines of CAD, GIS, visual simulation, scene reconstruction, rendering methods, surveying and remote sensing techniques.
This research presents the improvement in the presentation of the results in a GIS dedicated to a cross-border spatial databases connecting the Prealpi Giulie Nature Park (Italy) and the Triglav National Park (Slovenia). We created a consistent transnational reference dataset based on the common GI standards in terms of content, structure and quality (Barborič et al., 2006). We developed efficient methods of data processing and data diffusion to improve this transnational spatial information system producing a Geo-portal by means of the Open Source software MapServer (Malinverni, 2007). This could help the investigators, located at remote sites, to support via Internet the real-time decision making and the crisis management.
This project worked with different aspects of landscape, developing some scenarios, to improve the understanding of the landscape changes and to allow a virtual walk inside the park area. The 3D flight over the Prealpi Giulie Mountains, in the North-East of Italy, is very suggestive and can be useful for the knowledge of the environment. We collected technical and thematic typologies of information in the GIS, to make more explorable the three-dimensional scenery. We solve this task by means of Virtual Terrain Project (VTP), an Open Source software suitable to construct any part of the real world in interactive 3D digital form. VTP is inserted in the free and commercial software group for the 3D data representation and exploration such as Google Earth, 3D Nature, LandXplorer, Scene Express, OsgPlanet (OSSIM), DbMAP Web 3D, ArcGIS 3D Analyst and ArcGlobe, etc. VTP supports a set of software tools: VTBuilder, which elaborates geo-referenced data to represent them in two dimension and Enviro, which creates virtual three-dimensional environments and allows the 3D navigation. These tools and their source code are freely shared. Every data management is performed by internal routine but it is possible to personalize them for specific purposes.
The management of the 3D data lets to work at different levels of detail. Fluidity of movement is a fundamental requisite to allow that the greatest number of possible users enjoy the same data. In fact the simulation and visualization of complex environments in the past were exclusively for a local use, above all for the great dimensions of the data. Now recent techniques of compression, new data formats and new procedures help the Internet connection. Integrating these techniques with GIS functionalities it is possible to create a devoted system for the analysis and the assessment of environmental impact.

2. CARTOGRAPHY IS CHANGING: THE VIRTUAL-GIS IS COMING

The Web is actually a vast collection of interconnected documents, spanning the world, which merges the techniques of networked information and hypertext, to make a powerful global information system (Peterson, 1996).
At the same time, cartography is changing. More people are involved in making maps and in the use of these. But these maps are changing from a static product to a dynamic one that facilitates the visual thinking. This process is accelerated by the opportunities offered by hardware and software developments which have changed also the needs for the geo-referenced data. The changes require a different type of cartographer that uses interactive maps to solve his problems and makes new discoveries. It requires an immediate and real-time access to the data that allows a dynamic presentation and user interaction, based on new mapping techniques, not seen before with traditional printed maps (Kraak, 1998).
Initially, the Web was used simply as another medium to present spatial data. Successively the Web lets the admission to many users to the geographic information at minimal costs and with an easy access. Unfortunally the interactivity and the ease of use of Internet, in this moment, is yet limited by the technology performances. Users are generally impatient people and lose interest and go to other sites when the information takes too long time to download. This is a problem, such that the abbreviation WWW is sometimes said to mean “World Wide Wait”. The storage size problem is more critical with regards to download time and might reduce some of the benefits of map distribution via Internet, especially when there is a high degree of interactivity in the map.
Another user need is the capability “to click on something” this coincides with the need for interactive geo-explorator tools. In fact in relation to this performance, the need for interactive tools is relevant.
But which are the available tools to manipulate and visualise the data?
An important distinction is between static and dynamic maps. The first approach offers, starting from elevation data and related image textures, some static geometries at different resolutions and traditional map images. The second one produces animated maps, multimedia elements and virtual worlds. The virtual world, with respect to the traditional maps, offers 3D realistic views of the landscape, either as static pictures, pre-set flights or even fully interactive 3D models. The interactive versions are performed generally by media players in AVI, MPEG or Quicktime format. The animations created via VRML or Quicktime VR offer the best interactivity. These formats store a true 3D model of the objects, not just a series of 3D views. Using these techniques, the “Virtual Worlds” can be created and offered to Internet users.
Starting from this question: "I have these geospatial data what can I do with them?", we have discussed different aspects of map representation and diffusion and we have concluded that the Web Cartography has become an important new output for spatial data dissemination.
The application started using the geospatial data collected in the Geoportal created for a European research (Interreg IIIB – CADSES called “SISTEMaPARC”), based on standards and specifications coming from ISO, CEN, OGC, W3C. It is an organized database accessible by Web pages which helps to discover and to access to a wide variety of geographic information aspects. For the construction we used one of the most known Open Source software: UMN Map Server, freely downloadable from the official site http://mapserver.gis.umn.edu. We gave collected spatial and thematic data both in raster and vector format performing in the GIS the spatial data homogenization.
The Figure 1 shows the Corine Land Cover (CLC) thematic maps without gaps along the boundary of the Italian-Slovenian park areas. Into the transnational Geoportal there is also the possibility to display the DEM representation in a static way (a simple raster image). In the next paragraphs we present the improvement of the project regarding the realization of a dynamic and interactive 3D environment, always by means of Open Source tools.

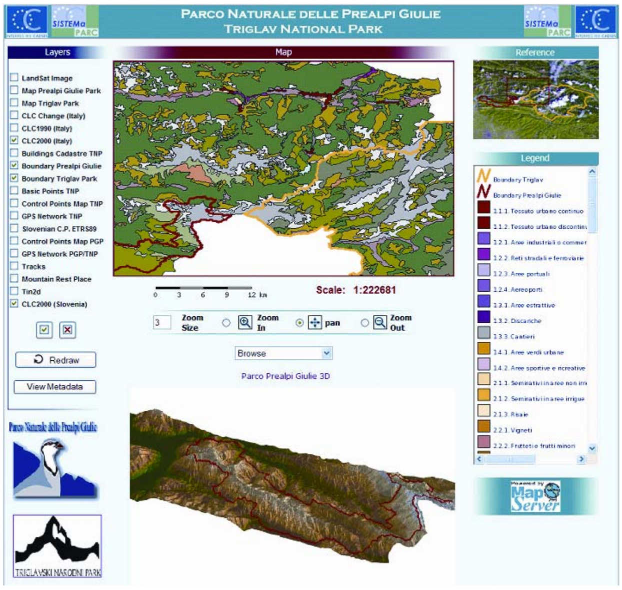

Figure 1 The Geoportal with a 3D static representation of the Prealpi Giulie Nature Park DEM

3. OPEN SOURCE GENERATION

The Open Source movement promotes the open access for the production and design process of different various products, resources and technical advices. The term is most commonly applied to the source code of available software without intellectual property restrictions. This increments individual effort and collaboration. Infact the user can study the source code for any purpose, adapt it to his own needs, and redistribute it, modified or unmodified.
The term Open Source gained popularity with the success of Internet. Since the early 90s, it becomes an alternative terms for free software into common use, but it is much more of this. The term Open Source quickly became associated with a different approach, a different philosophy, different values, and even a different criterion for which licenses are acceptable. The term *copyright* came substituted with the term *copyleft* which underlines how during the redistribution of the code it must be mantained the same licence of the original one.
To avoid talking about the impact on freedom of non-free software, the most common alternative terms are: "Open-source software", "Software Libre", "FLOSS" (Free/Libre/Open-Source Software) and "FOSS" (Free and Open-Source Software).
Many advantages of the Open Source software are fully applicable to the geospatial domain. In these recent years the GIS community find in the Open Source environment the tools useful to solve the tasks of management (QuantumGIS), visualization (Virtual Terrain Project) and dissemination (Map

Server) of geospatial data.
Also the Italian community of consumers and developers of Open Source geographical software is present with the web site GFOSS (Geospatial Free and Open Source Software), coming from university and research centers. GFOSS is active in the translation of applications and documentation in Italian language and moreover in the realization of original documentation. Another aim is to make freely available geographical data of good quality for personal and professional uses. GFOSS is not against the commercial software, and respects its importance in the geographical sector, but sustains that the free software is able to play an important role in the geospatial sciences. After all, the availability of the free GIS and related tools is a good alternative for the consumers, the industry, the research, considering the large community which exchange problems and solve them.
In the following paragraph we point out the use of Open Source software to realize a 3D Virtual GIS.

4. VIRTUAL TERRAIN APPLICATION: AN EXCITING 3D ENVIRONMENTAL VISUALIZATION

To manage information in a three-dimensional interactive and flexible way and to integrate multiple data sets in Virtual GIS one can use the Virtual Terrain Project (http://www.vterrain.org/) (Discoe, 2005).
This platform performs the simulation of navigation through 3D multi-resolution datasets coming from GIS with good performances. The tools and their source code are freely shared and so accelerate the adoption and development of the knowledges. In fact ssince the full source code is available, the developers can customize the 3D environment to meet their needs, adding their own value and even redistributing it.
It contains special tools for the visualization and publication of the geographical data. One is VTBuilder which allows to acquire both DEM files and texture images and processes them for the next 3D visualization step. The other one is Enviro which adds the 3D representations of vegetation, the building models and roads, imported from Computer Aided Design (CAD) or from GIS data files even converting between multiple spatial coordinate systems. Enviro gives an experience that is interactive both in terms of viewing that of scene manipulation. It displays the results in a variety of ways, realizing a very good terrain render by means of procedural scene reconstruction and rendering algorithms, selecting shadow and other realistic effects. You can set the elevation exaggeration, the background colour, the sun azimuth based on the geographic position of the viewer.
We performed the possibility to vary the color of the ground according to the height and assigning these changes of color to the ground passing from the dark green of the low valley to the white of the snow on top of the mountains (Figure 2).To increase the realism then we used a Landsat remote sensing image to texture the DEM.
The GIS project must be constructed at the bottom of the working phases of terrain modelling and landscape real-time reconstruction. 3D model can be modelled with a particular attention to its use in real time and in the Web and it has a geographic correspondence in the GIS.
The useful GIS data for Virtual Terrain Project consists of DEM, Geoimages and Culture data. This last is every thematic vector layer that describes a landscape: rivers, roads, trees, fields, etc (Figure 3).

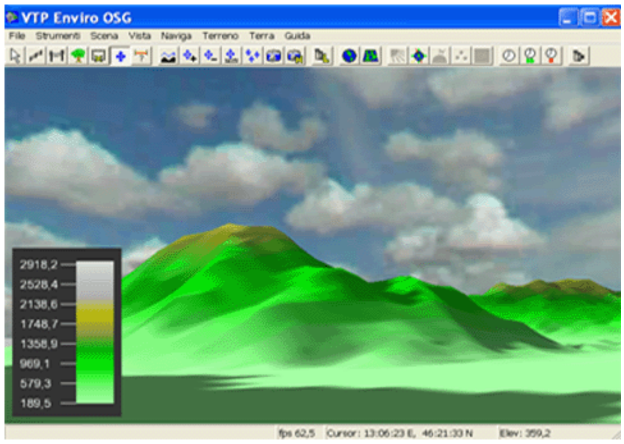

Figure 2 DEM visualization processing by colour code for height

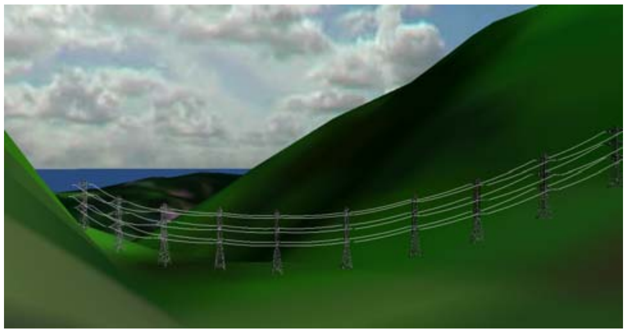

Figure 3 Technological elements localized in the landscape helps the impact assessment.

The vector layers containing building shapes can be viewed in the 3D model as solid building blocks. We have positioned several objects in the 3D view of the landscape and set various attributes of their field of view determining what any observer can see localized in the landscape. The Figure 4 shows an example of implemented XLM code related to the roads.

*<Roads>**true**</Roads>*
*<Road_File>**sentieri.rmf**</Road_File>*
*<Highway>**false**</Highway>*
*<Paved>**true**</Paved>*
*<Dirt>**true**</Dirt>*
*<Road_Height>**0.000000**</Road_Height>*
*<Road_Distance>**5.000000**</Road_Distance>*
*<Road_Texture>**false**</Road_Texture>*
*<Road_Culture>**false**</Road_Culture>*
...
*<Type>**Files Strctture**</Type>*
*<Filename>**prealpi.vtst**</Filename>*
<Visibility distance>**20000**</Visibility distance>.

Figure 4 XML code sets the parameters to geo-visualize the roads

For the vegetation data processing we used the some 3D geometric libraries. Consulting the Web site of the administration of the Prealpi Giulie Nature Park (www.parcoprealpigiulie.org/), it was possible to obtain some thematic information: for example the characteristics and the site where you can find some kinds of vegetation in relation to the different altitude. Then we searched the same kinds of trees inside the libraries of Virtual Terrain Project (more than 350 different kinds of trees and bushes coming from every part of the world). Another possibility was to extend and customize the software reconstructing the trees specifying many details (the trunk, the branches, the foliage, the height, etc.). The special typologies that we meet across the mountains of the park are the result of the join action of two fundamental ecological factors: the particular climatic domain of the zone and the geologic substratum. These factors determine an oceanic climate that allows the development of a very rich and diversified vegetation constituted essentially by *Castanetum*, *Fagetum* and *Piccetum*. Raising the elevation, the vegetation becomes bushes and the ground rockier and over the 1600 meters of altitude the woods leave the place to the grasslands (Figure 5).

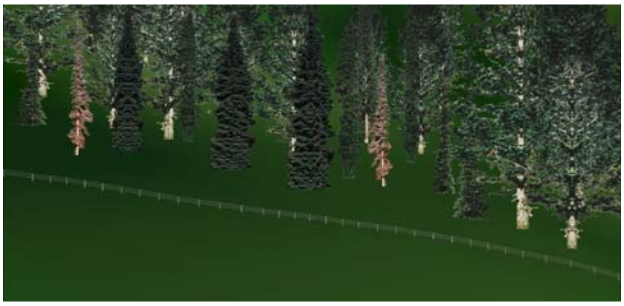

Figure 5 The diversified vegetation behaviour

We drew the abstract data such as city names or other thematic names coming from GIS layers simply as text in 3D (Figure 6).

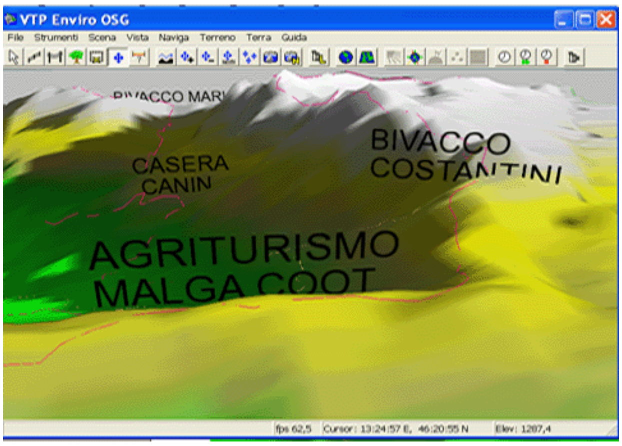

Figure 6 Thematic information on the 3D environment

On the contrary we found a big problem during the generation of the three-dimensional scenery of the rivers by Enviro. We had not the possibility to create the rivers in the same way which we solved, in automatic or manual way, the roads, the paths and the buildings. The reason is that there is not yet a good way to render in a realistic manner the water bodies on the terrain a cause of their dynamism. Maybe in the future it will be possible thanks to the further developments of the code.

We have to point out that the GIS background is always given: everything is geo-referenced (Figure 7). Moving the cursor around the 3D image the coordinates and the elevations are shown and the software takes care of projections and coordinate transformations. Of course the perspective view that is actually shown on a two dimensional computer screen is not really three dimensional, but something commonly called “pseudo–3D” or “2½ D”.

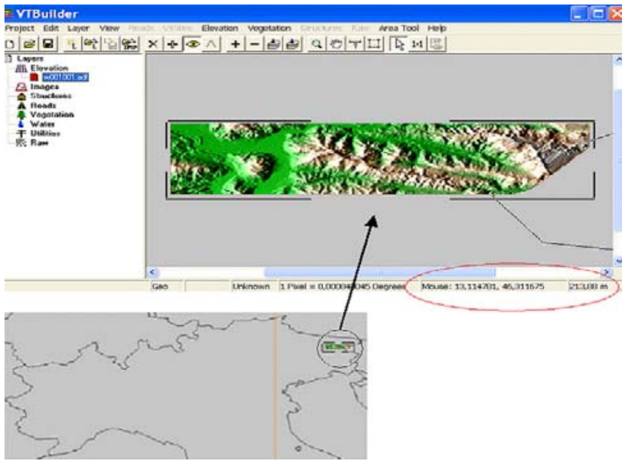

Figure 7 The correct localization in the reference frame of the map

When you manage and reconstruct large territories the data dimension (in term of memory, number of polygons and textures) is a problem. The created geometries can be subdivided into a LoD hierarchy according to user position. The smoothness can be achieved through the use of the multi resolution rendering. The objects farther away are rendered at a lower resolution than the objects closer to the observer (Figure 8).

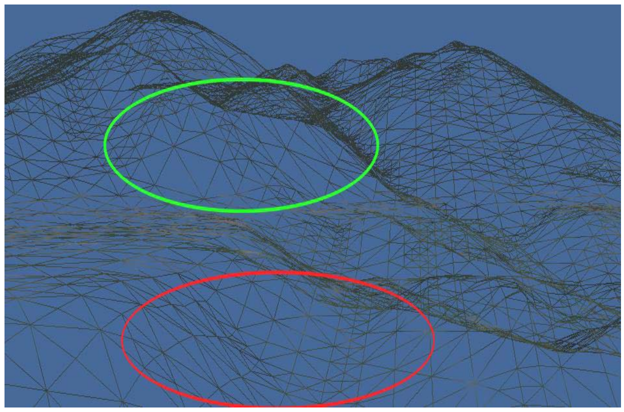

Figure 8 Efficient use of the LoD algorithm in the surface display

This simplification can be applied also to vegetation and buildings representation. The result of this is that the appearance of the 3D views is excellent and overall fast. Also the Landsat image is draped on the ground efficiently via Continuous Level of Detail (CLoD) (Figure 9).

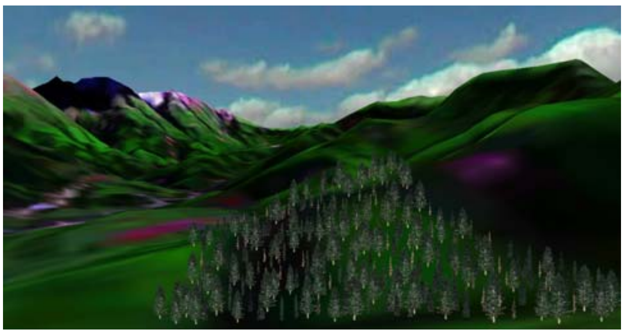

Figure 9 The DEM textured with the remote sensing image

After then we saved a series of 3D views, by the flight path method, in several digital movie formats.
Enviro provides an interactive, real time 3D navigation in two view modes: Earth View and Terrain View. After the organization into 3D geometry, it gives to the user a host of capabilities from navigation and waypoints to editing the scene, such as planting trees and moving buildings.
After the processing and the changes in Enviro we obtained a complex landscape geo-visualization ready to Web publication (Figure 10).

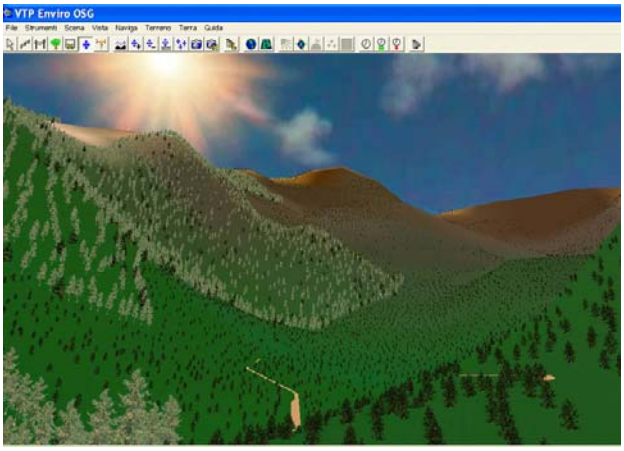

Figure 10 The complex landscape geo-visualization ready for Web publication

5. THE WEB SOLUTION BY VTP

The developed application for Web navigation of the three-dimensional landscapes, in real time behaviour, uses some Open Source libraries included in the VTP.
The platform Virtual Terrain Project supports the terrain generation, importing and exporting some well known file format, by the OSG (OpenSceneGraph) (www.openscenegraph.org) libraries. In comparison with the other known libraries it has some interesting peculiarities: it can manage the most used 3D data, images, streaming, formats; moreover the OSG is a cross-platform that can be transferred easily toward other different architectures, windowing system independent (Pescarin et al., 2005).
Once defined the elements that would be due to serve as the section of Virtual Reality Web GIS, we directly exported them from Enviro in a useful format for the publication on Internet.
It is possible to export *Culture* data as single files osg or other compressed file format ive, or as data according to a grid inserting them directly in the tiles. The user can choose in Enviro what to export and how to do it, modifying and reconstructing the SceneGraph. For example we defined the *Culture* data as 3D OSG objects in the scene (buildings, vegetations, labels, etc.).
The three-dimensional layers in the export phase have to be organized in hierarchical levels and connected to the same hierarchy of the ground resolution, so that to be able to be managed in optimal way during the Web navigation. In fact the hierarchical organization of the scene allows to visualize only the elements closer to the point of view of the consumer determining the level of detail. This makes fluid and fast the navigation to everybody.
Using OSG modules it is possible to access the data from a remote source. An ActiveX plug-in for Internet Explorer is able to find data, generated by VTP, in a Web server, activating a real-time navigation on the scenario (Calori et al., 2006; Forte et al., 2007). The presence of a library that extends OpenSceneGraph methods can define exportable scene-nodes.
After a first stage which generated the terrain database (the three-dimensional ground in" tile" with different levels of detail) and put inside the 3D environment all the other useful GIS information, the publication phase started. In fact the last phase is the insertion of the data inside the browser and the generation of a level of interactivity, to allow the simple navigation in the park area. In order to navigate inside remote on-line landscape we used a component ActiveX. This interface, available in code JavaScript, allows to select the different points of view and the different layers and alternative models. The generation of these pages is dynamic.
The ActiveX is free downloadable from http://www.vhlab.itabc.cnr.it/Downloads (Pescarin, 2007).
Finally all kinds of data were organized allowing to the users to browse for information in an interactive geographical environment.

6. CONCLUSION

This project has shown the realization of a platform for the management and the realization of real-time scenarios of the Prealpi Giulie Nature Park landscape by Open Source tools. This enable public participation in environmental management underlying how the visual qualities are useful to understand the changes of the territory and can become a big support for the decision makers.
The Virtual Reality on Web is provided by suitable plug-in to realize good performances.
The Virtual Terrain Project was demonstrated a suitable Open-Source software for easily constructing any part of the real world in interactive 3D digital form.
Often it is important to choose between an open solution and a closed one, since many open formats and standards allow for interoperability. We believe that this kind of applications and this kind of approach will have more and more fields and benefits.
Finally we can conclude that the Virtual Reality based on GIS gives the possibility to exchange information, to open discussions, to test and review different hypothesis for cultural content dissemination, at different level, without loosing any scientific precision.

AKNOWLEDGMENT

Thanks a lot to Juri Corradi and Stefano Brambilla which have processed the data during their graduation thesis.

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