# VR Web based tree and vegetation representations for environmental applications and studies, an example on ChongMing Island

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Abstract: Realistic visualization of crops, forest, peri/urban, natural scenes raises high interest under the environmental pressure and social demand. Unfortunately, despite the capabilities of the Internet and graphic boards, virtual landscapes and scenes are still restricted to small-scale user communities, with low dynamics, low aestheticism, low respect for biophysical laws. Web large-scale VR vegetation scenes are a challenging topic, due to the complex geometry and its rendering; and due to the lack of efficient modeling method and dynamics understanding. Moreover, VR must involve close objects that can interact easily with contextual background objects as to settle applications. However, specific solutions exist, and some of them can be used for WebVR display: light weighted static plant models, paged landscape map geometry, procedural vegetation generation on the fly. Reconstructions from photos, mixture of real and synthetic images in augmented reality are also of interest for this topic. On the study case "the Ecological project of Chinese ChongMing Island", new techniques are shown: Plant billboards and hybrid models, VRML classical scenes of historical farms, and guided maps with 3D web flash panoramic spot views. Perspectives are finally exposed from new developments: rule based geometry generation Web browsing, fast reconstruction from image models, high-level simulator output, with a background of new Web and graphical hardware approaches.

Keywords: Reality (VR); Web visualization; virtual landscape; virtual crops; image-based 3D reconstruction; billboard; hybrid models; VRML; rule based drawing; real time rendering

# Introduction

With the growing concern for environmental issues, is rising the interest for the realistic visualization of crops, of forests, of peri/urban areas, of generally speaking natural scenes - i.e. landscapes. This topic interests players and decision makers in the definition of land planing, land use policies, local economical developments, ecological and biodiversity preservation. It interests also the research communities studying the dynamics of our environment, and allows cross disciplinary exchanges up to public communication.

Tools related to virtual landscape visualization can be classified in two classes: firstly scientific visualization, aiming to understand the simulated dynamics, and secondly communication tools, aiming to share possible visions of the future between officers and public. In this paper we focus on this last aspect, requiring tools easy to use, intuitive, interactive, open to a wide public. The use of the Internet to walk through existing or simulated landscapes seems thus obvious and gives sense to "Web based Virtual Reality landscapes representations".

The purpose of this paper is to give some ideas of possible threads and that could make Web based natural VR scenes popular at mid and long term for environmental applications. Citing common difficulties on the topic, the second section points out some past works of interest. The third section introduces briefly some techniques we used and developed in the frame of our research network, and how we combined them to develop navigation and visualization for an environmental project, mixing real and virtual scenes.

# 1. Difficult points, related works

Web large-scale VR vegetation scenes is in fact a challenging topic, due to the complexity of the scene component representations and behavior towards light. Natural objects are difficult to describe, their shapes are related to complex evolutions, which are difficult to be computed, due to the lack of efficient modeling methods and the lack of their dynamic's understanding. Moreover, on the model of any VR applications (CAD-CAM for instance), VR applications must involve strong user interaction, not restricted to a simple walk or fly navigations and fast loading (transfer) costs. Users must interact with the objects of the scene, emerged in a contextual background, and those objects react to user decisions. In Computer Graphics, "natural phenomena", the so-called natural environment modeling and visualization emerged since its early age, due to the complex, heterogeneous, multi scaled and dynamic phenomena involved in the various components building landscapes.

Nevertheless, specific dedicated tools, but not Web based, are available on the market. Among them, one can notice LandSim3D from Bionatics SA (Bionatics, 2010) as being one of the most complete and powerful, bringing a solution to professionals. More computer graphics oriented, World construction Set, Visual Natural Studio (World Construction Set, 2010) are also mature tools. Landscapes design tools are often completed by project browsing tools, usually free, allowing partners to walk thought virtual landscapes. Some are Web based, but all restricted to a specific editor (Web Scene Express only supports WCS and Visual Natural Studio Scenes).

In the research and wide public area, partial solutions do also exist. Tools such as SLE-Seamless Landscape Explorer (Griffon, 2009) generated in the frame of the European collaborative projects SEAMLESS (Van Ittersum, 2008) use light weighted static plant models, paged landscape geometry, procedural vegetation generation, an user friendly interface, connected to a GIS. Game industry plays a key role in the development of interactive natural scenes, as it can be shown by the impressive modeling and animation research work of Crysis company (Sousa, 2008) using the SpeedTree rendering approach (Kharlamov, 2008), but being still far from biological dynamics and rigorous exploitation.

The Web 3D VR language, VRML and its current extension X3D (Don Brutzman, 2007), are seldom used for landscape applications. Among different contributions, the work of T. Honjo and his team are obviously pioneer (Honjo, 2001). He was one of the first to offer to the Web community, walk through forest and urban park scenes. However, despite progresses, this work did not receive major supports and explores superficially the potential from WEB.

# 2. VR Web Techniques illustrated on a project case.

South of France Languedoc-Roussillon and Shanghai province do cooperate on an ecological project on ChongMing Island (Agropolis, 2008). A subtask of the Ecological project is dedicated to visualization, giving the opportunity to mix and integrate several approaches: plant billboards and hybrid models, VRML classical scenes of historical farms, and guided maps with 3D web flash panoramic spot views.

## 2.1. Vegetation scenes

In this study we defined vegetation from single plant models using two main techniques. Virtual simulated plants on one side, and hand designed on the other. Simulated virtual plants are obtained from Amap modeling approaches (Jaeger, 1992) or GreenLab (Cournède, 2005). The resulting geometrical plant models are heavy, we reduce the plant geometry complexity, using our branch and foliage compression and decimation dedicated tools (figure 1) (Deng, 2009).

*(a) 100%* *(b) 5.2%* *(c) 0.25%* *(d) 0.01%*

*Figure 1. Black Poplar Level of Detail models with their compression ratios (Deng, 2009).*

*Figure 2. Hand designed 3D tree model*

A single flat image is sufficient to display a plant. This technique, called billboard or impostor is classical in VR. Art designed trees were designed from popular 3DS Max tool (3DS, 2010) and use simple geometry for branches and impostor (figure 2).

Both techniques were used to generate VRML scene files. Dense vegetation fields are described by a simple location list, that can be generated by a planting tool editor -we use the free SIMEO tool (SIMEO, 2010), developed by CIRAD within the CAPSIS platform (De Coligny, 2007) . The scene, stored as a simple text file plant position list is then converted to a VRML file, referring to vegetation individual models through "#inline" calls. Each individual tree geometrical model can be defined from previously cited techniques. In the following example (figure 3), polygons and single billboard approaches are used.

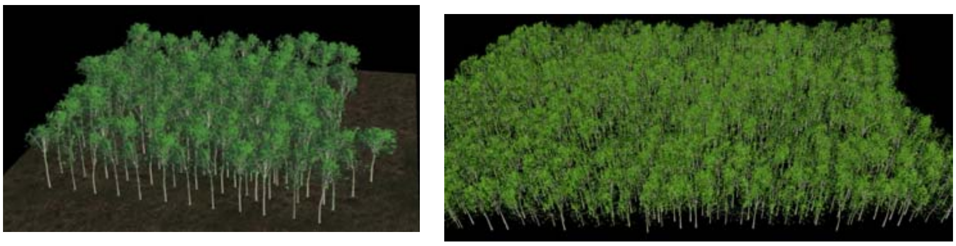

*Figure 3. VRML forests generated automatically from individual tree scenes. 120 single trees rendered as billboards (left) and 3000 trees rendered using low cost geometrical models (right)*

## 2.2. Linking geo-referenced co-ordinates to the study case and Web navigation.

In Agronomy, as well as is any environmental application, geo-reference data consistency is crucial. We chose therefore to base the application entries from the Google Map system. An alternate to Google Maps could be Google Earth, as chosen recently by T. Honjo and his team (Honjo, 2009). But Google Earth does not offer, so far, an Application programming Interface (API), and requires to be installed on purpose.


*Figures 4a and 4b. Google map entry (left) and navigation tool (right)*

Google Maps allows also access to navigation and local requests. Technically speaking, we implemented the Web navigation based on Google Map by calling Google Map API. If users input source location and destination, the navigation system can return an optimal path from source location to goal visually (figure 4b).

## 2.3. Hot spots images from real world presentation

Google Maps offers also the possibility to explore locally hot spots thanks to image based techniques such as Street View. We chose a Panorama browser approach, since our application is in rural conditions, without StreetView as data, and data picture acquisition can be done from our own. We developed a new Web panorama player with free plug-in installation, based on PaperVision3D (Tondeur, 2009). The interface is easy to use (figure 5). A serial of panoramic views were taken on ChongMing Island, at different spots with a high resolution digital fish eye lens camera in Qianwei Village. Hot spots corresponding to these locations were added in Google Map navigation. When the user clicks on a Google Map hot-point (figure 4a), the corresponding Web panorama roaming system is popped up (figure 5).

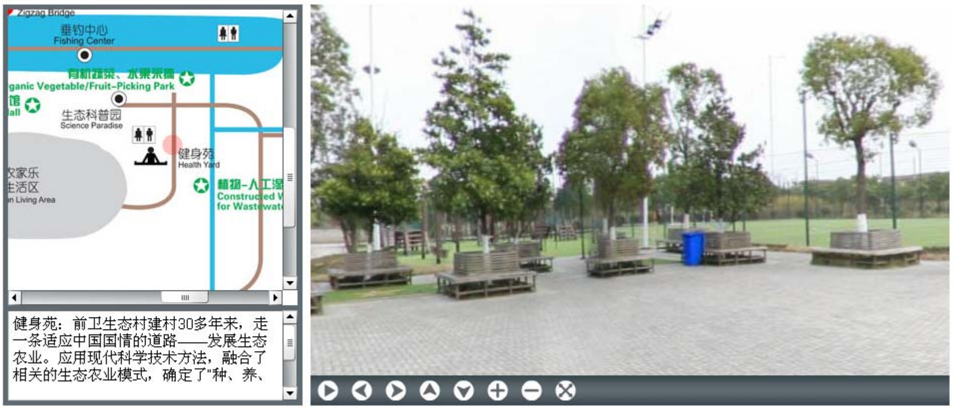


*Figure 5. Panorama Roaming System. The hot spot of Qianwei Village*

## 2.4. Virtual 3D scenes

We have also developed a set of VRML 3D scenes related to Qianwei village by using our proposed lightweight modeling methods. We have reconstructed an historical farm and also a small temple site. Two corresponding snapshots are shown below (Figure 6). Such scenes are also popped from the local maps.

*Figure 6a and 6b. VRML 3D scenes, historical old farm (left) and old temple (right)*

So far, we do not involve any digital elevation model or altitude information in the project. We are currently constructing 3D crops scenes corresponding to agronomic trials.

# 3. Future works, current advanced research trends and perspectives

The future capabilities of Web VR applications for environmental studies lie on three main streams:

- at short term, the capability to reach the same quality with less information to transmit and draw,
- at mid term, the graphical (and more widely the client hardware and software) capabilities to generated geometrical details, illumination calculations and 3D displays
- at long term, the models capabilities to express their dynamics and interact with user requirements

Vegetation simulated models restrict the visual and transmission performances in VR. The geometry sent to the client must drop down. The use of the plant structure is a key: it helps to reconstruct the geometry if necessary and only if, with the appropriate detail. As an alternate to simulation, plant reconstruction from images (Tan, 2008) and 3D scans become more popular (Cheng, 2007). For both sources, plant structures should lead to construction rules. Such rules can then be re-used for the plant generation (Sun, 2009) in the Web browser.

High performance Computing becomes popular thanks to the efficient use of the Graphical Board Unit for general purposes so called GPGPU. More applications derive the graphical capabilities to general computation purposes. This opportunity shows, at mid term, the potential to compute (generate) costly geometry in the graphic board, on the client.

As done in the dedicated fore-mentioned land-use tools such as SLE, LandSim, etc, Web based browsers must show the capabilities to use paged geometry and procedural vegetation seeding. As the distance to the viewer decreases, the information related to the landscape composition should become available; the corresponding land map must involve more layers consisting in trees, shrubs, small plants, and other small objects to be generated just before drawing, on the basis of predefined biotypes in order to complete the illusion of natural complexity.

Finally, visualization of dynamics is the future key issue of environmental representations. Evolution representations may concern land use dynamics, that can be modeled by grammar rules (Gaucherel, 2006), or biophysical phenomena such as plant growth models coupled with water resource models (Le Chevalier, 2007). Recent impressive GPU based approaches on wind sand simulations (Wang, 2009) show that fast dynamics simulation and visualization based on classical physics become feasible... so why not complex multi model dynamics at landscape levels ?

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