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Web based teaching about complex cultural building

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Abstract: - A permanently increasing graphical power of commonly used computers opens a possibility to present highly detailed and richly textured three-dimensional models of cultural complexes using the web. Utilizing virtual reality paradigms, both experts and ordinary users can explore pieces of cultural heritage in a virtual environment. The paper presents briefly an overview about Virtual Reality and web-based application (state-of-art, languages, file format and other technologies that are used to deliver 3D content on-line) together with several practical observations concerning efficiency of the real-time rendering and the level of implementation difficulty. Moreover, it introduces an experimental virtual environment for web-based teaching that reproduce an important church in Bari: Basilica of Saint Nicola.

Key-Words: 3D Reconstruction, E-learning, Virtual Environment, Web Technologies, Multimedia Training Modules.

1 Introduction

Internet and World Wide Web are providing an information resource of unrivaled breadth available to all at little or non monetary and technical investment various initiatives are employing this vast domain to improve services across multiple front to benefit all kind of users. As part of these initiatives, research is progress to identify opportunities for enhancement of information management, presentation, education and analysis, through application of Web-based 3D graphics by realizing virtual worlds utilizing virtual reality paradigms: Web 3D. This one is an overarching term to describe protocol, language, file format and other technologies that are used to deliver compelling 3D content over the 3D graphics representation. Through the mid-1990’s, the Web3D Consortium worked with the Virtual Reality Modeling Language (VRML) community to develop specifications for version 1.0 and 2.0 of the VRML that is a language for describing 3D scene as a scene graph: hierarchical decomposition of the renderable component in a scene. In 1997 the ISO (International Standard Organization) established the VRML specification as international standard. Subsequently, VRML has enjoyed use as a WEB3D graphics language through numerous implementation (e.g. Parrallelgraphics Cortona, Blaxxun Contact) available as plugin for common web browsers (e.g. Microsoft Internet Explorer, Netscape Navigator) VRML is also widely used as a 3D graphics interchange format. VRML has wide support in programming tools. For instance, professional animators create content using the popular high-end 3D animation program (3DStudioMax, Creator, …) and then use the build-in VRML export function to create the VRML file. A modeller produces a result that can be truly professional-level VR, however, VRML browsers and plug-in tend to be large that translate into long download on common personal computer. For instance, Cosmo Player, a popular VRML-compatible plug-in, requires a download over 3.2 Mb for the Windows/NT version. The large size of browser and plugins makes innovation more difficult because each new feature has to be integrated into and tested with a complex existing feature set. VRML applications have also had serious problems with performance and reliability. The next generation specification for VRML is the Extensible 3D (X3D) standard. X3D is a scene graph and text based encoding designed to overcome the limitations of the VRML standard. X3D extends the capabilities of VRML using XML (Extensible Markup Language). XML is flexible and extensible: it basically just describes rules that enable user communities to define the HTML-style tags they require to represent structured data. The objective of our experimentation is to put on-line a three-dimensional model of the Basilica of Saint Nicola in Bari, Italy.

Sure this isn’t the first application of that kind and internet is full of similar models but they are very simple. The challenge consists of to give to every user (even if his hardware is obsolete and his internet connection is slow) the possibility of a easy navigation in the our model at a good quality of visualization. So, we will optimize our model by applying the necessary techniques and we will determinate the best standard for 3D graphics.

2 Web and virtual reality (VR)

Virtual reality (VR) offers new dimension for presentation of spatial (3D) objects that are a creation of 3D model geometry, materials, lighting and rendering. Current graphics-acceleration hardware has eliminated previous frame-rate impediments and many complex scene are now rendered quickly and at better quality. As more and more people utilize 3d worlds and user interactivity becomes a dominant requirement. One of the main advantages of VR is the possibility to explore the 3d worlds of any point-of-view and at any level of detail in real time. This sort of exploration is very user friendly because he behaves in virtual reality in similar way as in a real environment. A very important advantage of VR is easy availability of virtual models by means of Web. For such purpose, a VRML language is widely used. The user has a full freedom to move in virtual reality environment in contradiction to movies where the trajectory has been predefined. But the data volume transmitted in case of virtual models is in orders less than in case of movies. There are, of course, some disadvantages of virtual reality technologies in comparison with some other technologies: as a disadvantage we can consider the necessity to install VR viewer/browser. The quality of images is, in general, lower than in case of other technologies (movies, images, etc…).

There are 4 aspects to interactivity in 3D graphical content:

- Movement: object in the virtual world can move independently, relative to each other and relative to the viewer's viewpoint;
- Navigation: the viewer can effectively look about and move within the virtual world, without getting disoriented or "lost in the cyberspace";
- Responsiveness: the viewer can initiate abject changes and trigger embedded behaviors and motions within a scene, usually based on realistic or plausible logic;
- World models: a significant amount of world information is available, either via a local database or via shared network resources.

Trough these characteristics, the viewer is not constrained to remain a passive observer of the rendered scene, but can also became an active participant in a scene. All together these characteristics help the viewer attain a scene of autonomy, immersion and presence in the 3D scene. The phrase "Web3D content" refers to 3D graphics rendered via a web browser, such as Microsoft Internet Explorer or Netscape Navigator. 3D content need to be as easy to access and view in a browser as 2D text and graphics in a Hypertext Markup Language (HTML) documents are today if similar scalability, ubiquity and "easy to use" are be attained.

The Web3D Consortium Incorporated is a non profit organization dedicated to the creation of open standard specifications and recommended practices for Web3D graphics. The Web3D charter goal is to accelerate the worldwide demand for products based on these standards trough the sponsorship of market and education program. From the prospective of the Web3D consortium, Web3D is an overarching term to describe protocols, languages, file format and other technologies that are used to deliver compelling 3D content over the World Wide Web.

Established in 1994, the Web3D consortium today consists of leading-edge companies and technical experts from around the world working together to design, develop and promote open, interoperable and standardized technologies, standard, tools and technologies. The Working Groups operate on the following topics:

- conversions for building multi-cast-capable, large-scale virtual environments;
- extensible 3D (X3D) specification: design, develop, implement, evaluate and standardize the X3D/VRML 200x specification;
- source code management: manage and develop open source and community-source code contributions
including the Xj3D (Java-based) loader/browser and Blaxxun's Contact (C++ based) browser;
- GeoVRML: determine method for representing geo-referenced data in VRML and develop tools necessary to generate, display and exchange such data. GeoVRML 1.0 is currently a Web3D consortium Recommended Practice;
- Humanoid Animation (H-Anim): create a standard VRML representation for humanoids. H-Anim 1.0 is currently a Web3D consortium Recommended Practice;
- Distributed Interactive Simulation (DIS) : Establish networking
- Universal Media: define a small, cross-platform library of local resident media elements (textures, sounds and VRML objects) in a uniform mechanism by which VRML content creators can incorporates these media elements into their worlds.

3 Virtual reality modeling language (VRML)

Simply stated, VRML is a language for a describing 3D scenes. The language uses the scene

graph paradigm: a hierarchical decomposition of the renderable components in a scene expressed as a text, VRML files are readily accessible over the internet and can be written and modified using simple text editing software. In general, the VRML language syntax is fairly hard to learn and debug without the use of an authoring tool. On the other hand, a strength of the standard is that graphical scene can be created directly through text editing and those files can be readily shared over the net. since establishment of VRML as an international standard in 1999, numerous authoring and rendering tools, including plug-ins for common internet browsers, have been developed and made available to the public as freeware or commercial products. In addition, many 3D authoring products now provide the possibility to import and export VRML formatted capability to import and export formatted files, enhancing interoperability across multiple formats. All these aspects have contributed to VRML becoming the most widely used form of Web3D on the internet today. Unfortunately VRML browsers and plug-ins tend to be large that translates into long downloads on common PCs.
The large size of browsers and plug-ins, depends on the fact that VRML has an extensive set of required features. That also makes innovation more difficult, because each new feature has to be integrated into and tested with a complex existing feature set. VRML applications have also had serious problems with performance and reliability. Problems of speed and reliability have been exacerbated by the fact that VRML was perceived as not being freely extensible in a way that maintained interoperability among extensions.

4 Extensible 3D (X3D)
The next-generation specification for VRML is the Extensible 3D standard. X3D is a a scene graph and text-based encoding designed to overcome several limitations of the VRML standard. X3D uses the Extensible Markup Language (XML) to express identical VRML geometry and behavior structures. X3D is thus a backwards-compatible XML tagset for describing the VRML 200x standard for Webcapable 3D content. Such content is not static, but dynamic, driven by a rich set of interpolators, sensor nodes, scripts and behaviors.
The current X3D/VRML 200x XML implementation is capable of compatibly using all legacy VRML97 content through a VRML-to-X3D translator developed by the National Institute of Standards and Technology (NIST). X3D provides new interoperability with other relevant standards including MPEG-4 and an entire family of XML-based language. The full power behind the X3D representation is the underlying XML technology. As an XML document, the 3D scene is simply structured data, which can be processed in a variety of ways without concern for how the data should be presented. In this case, the X3D file describes 3D content, but that content need to be rendered as a 3D scene. Through Extensible Stylesheet Language Transformation (XSLT) the content in a X3D/XML file may be converted to VRML, pretty-printed to HTML, or converted to any number of other format (including objects expressed as source code). Expression of VRML scenes in XML enables application of a wide range of existing and emerging XMLbased tools for transformation, translations and processing XML is rapidly transforming the web from a vast document repository to a vast data repository. XML provides numerous benefits for extensibility and componentization. For X3D, XML further provides the ability to develop well-formed and validate scene graph, an extremely valuable constraint since it presents “broken” 3D content from being allowed to escape onto the web where it might cause large scene to fail.

5 Data acquisition and 3d reconstruction
Before we start to make 3D models of real objects, we have to answer the following basic question: How to represent 3D model? How to create/reconstruct 3d models? The first question deals with data structures, file formats, media. The range of answers is unfortunately too wide. We have three main concepts: panoramic images, polygonal models, point-based representation.

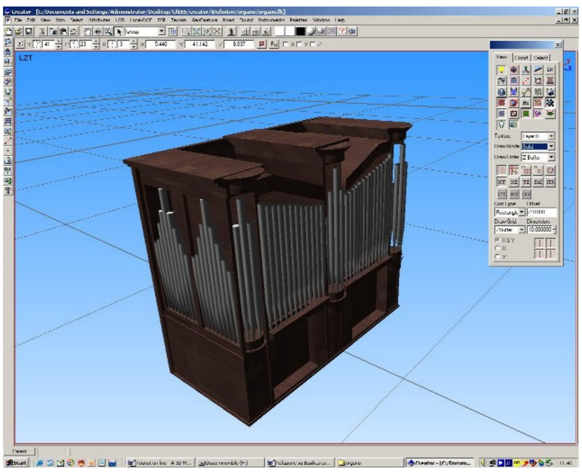

Fig.1 Multigen Paradigm Creator

File formats for each concept are diversified. A conversion between formats is not always simple and tends to loose precisions and application-related media. In the following text we concentrate on boundary (polygonal) representation of 3D objects. A practical approach is to use a modeler as Multigen-Paradigm Creator. MultiGen Creator is a tool set for generating optimized object models, terrain, and synthetic environments for use in real-time simulations and other visualization applications. Creator is designed to build real-time 3-D databases. There is no command or scripting language; just a hierarchical database structure controlled entirely through a visual interface. Users control object/sub-object structure, texture, lighting, the order in which data will be processed, levels of detail (LOD), at what distance LOD models swap in or out, placement of binary separating planes, etc. Texture mapping tools enable users to apply color, texture and materials automatically and interactively. A Texture Editor is integrated with a Custom Tool Palette. Internal double precision accuracy is maintained during the database construction process. Creator can import DXF, 3DS and OBJ files. Creator can export DXF, VRML and STL files. The second question posed at the beginning of this section is probably the most important issue on the way from real to a virtual world. It's important to explain why the Basilica. The selection of Basilica of Saint Nicola as a suitable subject arose from several circumstances: this monument is accessible, complete, ant it's the object of scholarly, religious and tourist interest.

Fig.2 Basilica of Saint Nicola

Before we start to design the model we collected any information about the Basilica: planimetry, photos and a series of measurements. Many photos were taken with a digital camera and every single photo has been used in several ways: panoramic photos has been used for to have an idea of disposition of single object. The more detailed photos have been used in order to reconstruct any object in detailed manner and in order to have good textures. The photos and the measurements have concurred to characterize the present structures and objects to the inside of the basilica and their best re-construction.

Every object has been created separately and then it has been

Fig.3 A particular stone seat

placed within the basilica model. In order to render the reconstruction more realistic, every object has been "texturized". At the end of work we have obtained a model of Basilica with a good level of similarity.

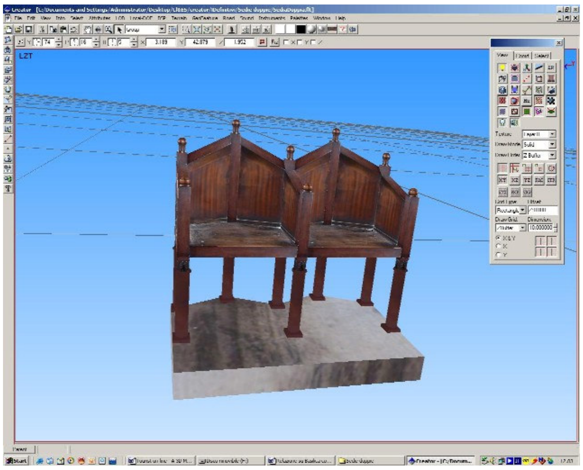

Fig.4 Reconstruction of the stone seats

6 Web-based presentation issues

After the previous step, we used the model as a standalone application, but using it like a web application is improbable because the amount of data is very large. Then, before to put online our model other transformations are necessary. Creator can export the 3D model into a webbased format like VRML.

This conversion often is not very well optimized. The following practice should be kept: where it was possible, we used primitive object (cylinders, cones, boxes, …) because they describe the object by a analytical description, not by mesh; repeatedly placed object/details defined via references, not by copy-paste method, in this way we reduce the amount of downloaded data; all texture downscaled to opportune resolution. Moreover it has been possible to apply one of the most efficient principles is known as Level of Detail (LOD). A model is described by several representation, from the most detailed to extremely simple ones. A presentation system switches among these representation in correspondence with a distance between a user and the rendered object. The LOD principles can be applied to the images we use as texture. If user is distant from the object that he's observing the system download a low resolution texture, but if the user approaches it, the system download a high-resolution texture that allow to see a better quality object.

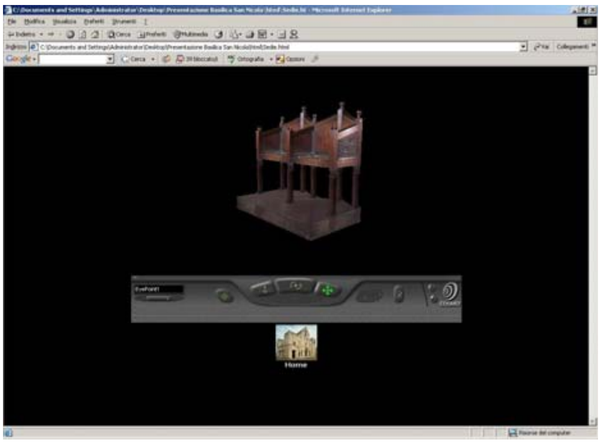

Fig.5 Rendering of the stone seats

With these techniques we can balance quality and speed and users can navigate the model easily: in fact users can begin to navigate the model even if it's not completely downloaded. In order to obtain a better performance we translate the VRML model by using the X3D standard.

7 Conclusion

This paper presented an approach to the 3D graphics and to 3D graphics on the web. In this moment we are at work to optimize other characteristics of our project: speed and quality of visualization. At the end we hope to test 3D model on-line: both VRML and X3D models and then we will compare the two standards and their performances. Sure a visit to the presented model doesn't substitute a visit to the real Basilica but it is useful in many applications and situations where for example access is critical or in e-learning environments.

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