X3D Experiences On A Hydro Junction Digital : A Case study of Three Gorges Dam

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Abstract

This work presents our experience in using Virtual Reality techniques to digitally reconstruct the World famous Hydro Junction-- Three Gorges Dam. This paper discusses the work undertaken by the China Water Museum to develop X3D-based Water Museum Virtual Reality System. This system is to deal with difficulties in applying 3D information system in virtual reality experience, which is written in Extensible-3D (X3D) and Java. In order to achieve an accurate 3D representation, the process was divided in phases to better structure and fundament such development: historical data gathering and analysis; 3D modeling and; interactive immersive visualization. Due to the nature of this project, different people from different areas of expertise were involved, working together in a unified development environment. It is our opinion that the online design review has achieved its objectives. However we identified some features that would improve collaboration such as digital 3D annotation and support for online collaboration in current X3D browsers.

Keywords- Virtual Reality; X3D; 3D Modeling, VRCluster; Graphics Rendering

1. INTRODUCTION

China Water Museum (CWM) is the only national museum of water resources, which is managed by the State Ministry of Water Resources and The People's Government of Zhejiang Province. CWM has about 36,000 square meters building area; The main building reaches up to 128.9 meters and has three exhibition halls. There are many water conservancy projects in three halls such as the world famous huge dam "Three Gorges Dam". The museum not only tells the history of water to the public, but also gives the experience in huge dam. Typically, visitors only get limited information from the guidebooks and videos. Visitors would gain in-depth understanding of the Three Gorges Dam from the Virtual Reality Experience System; they can overlook the Dam, open the ship lock, and enjoy a close-up experience of the spectacular scenes of spillway.

The well-known Three Gorges Dam project is being built at sapingduo, yichang, hubei province. The dam is 181 meters in height. its construction investment comes up to 203.9 billion RMB. The installed power generation capacity is expected to be 18.2 million kilowatts. With the dam built, the flood in the Yangtze River valley will be controlled; navigation improved besides the economic benefits. Tourism will be little affected. Many cultural and historical relics are now being removed to a higher ground before the rise of the water level approaches [1].

Using a 3-dimensional representation of such data and visualizing it in a VR environment could greatly improve elucidation and understanding of the Dam's architectural design. Although the Virtual Reality community have the expertise and knowledge to provide an improved experience for such demand, the users in our project domain (designers and architects) were not familiar or do not knew how to effectively use or program these tools. Moreover, its usability was not appealing enough for non-experienced VR users.

At a recent session on the use of VR in archaeology at the 2006 Computer Applications and Quantitative Methods in Archaeology (CAA2006), participants discussed their concerns of museum officials and debated over the solutions. Production of "This Old Digital City" (TODC), a historical VR exhibit that focused on the downtown district of Cedar Rapids, Iowa at the turn of the century. Results reported at VSMM 2001 by the developers of TODC demonstrated that the first few months of the exhibit's operation showed an increase in that museum attendance by as much as 89%, and over 100% increase in museum revenue [2]. TODC has demonstrated that VR exhibitions can do more than we imaged before.

In this context, our work tried to integrate both experienced VR users and experts from other areas in order to create an accurate 3D representation of Three Gorges Dam. A simple yet productive working environment provided both teams a fast paced collaboration and interaction through out the development cycle. The working process, divided in 3 phases (data gathering, modeling and visualization), needed close collaboration with the outside experts. This restriction imposed the use of 3D collaboration standards available for both worlds: an experienced VR laboratory and a group of inexperienced users of VR tools.

2. X3D BACKGROUND

Extensible-3D (X3D) can solve the exhibition and experience problem in many fields. Yvonne Jung and Ruth Recker [3] attained virtual medical anatomy based on X3D, but it just runs on local machine but not on the Internet. Marcio Cabral and Marcelo Zuffo [4] used X3D to reconstruct the historical and cultural heritage. Although we can browse it on the Internet, the scenes they created are

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fixed and cannot be modified. This paper applies X3D in the VR and implements 3D virtual experience system. By means of the client mode and scene rendering and management plug-in, using X3D's animation nodes and external JavaScript, a good interaction function was achieved. Meanwhile, we can add or delete scenes and models conveniently at the server according to the actual need.

In parallel with the development of the World Wide Web there has been a growth in the ability to model 3D objects on computers. The term Web3D is used for any method of displaying 3D data over the WWW. In the early 1990s the Virtual Reality Modelling Language (VRML) was developed to enable three-dimensional models to be displayed over the WWW. However, due to inconsistency of standards and plugins it has not seen comparable uptake to that of HTML. Recently a new standard, X3D (eXtensible 3D) has been developed by the Web3D Consortium [5]. This new standard received International Standards Organization (ISO) approval in August 2004 [6]. Whilst HTML and VRML were developed as complementary technologies, where one can exist without the other, X3D is an application of XML. X3D, given its relationship to XML, is seen as having a greater probability of achieving more wide-spread use than VRML. Dachselt et al. [7] suggest that the X3D format will be more successful than VRML due to XML-encoding, modularisation through profiles and smarter browsers (yet to be developed).

There are a number of ongoing projects using Web3D to create interactive visualisations of cultural heritage artefacts, from small museum objects too valuable/delicate to handle to complete cities that no longer exist. The Web is seen as a mechanism of making these

objects available to scientists, historians and the general public for learning and enjoyment. Most of the work in Web3D is concerned with the creation, storage and management of the virtual representations [8]. To date the majority of the work carried out has been based upon VRML, although the potential of XML and X3D in the future of Humanities Computing has been recognised by Niccolucci [9]. He identified the potential of XML as a means to rescue data from databases going obsolete due to software obsolescence and also to produce quality Cultural Virtual Reality with X3D. However he argues that there are significant difficulties to be overcome to enable practical application of the technologies.

3.SYSTM ARCHITECTURE AND KEY TECHNOLOGIES

This system uses B/S structure. The front client includes Experience sub-system and RS. Here, we develop the RS as a plug-in embedded in browser. Service includes experience hall management sub-system and scene and model management sub-system. There are three databases: hall management database, model management database and scene management database. The framework of WMVRES is shown in Figure 1.

The scenes and models of X3D format can be added to the database through scene and model management sub-system. Client sends a request to the server and the servlet in the server accepts the request and then decides which JSP file should be called. The called JSP then calls the JavaBean to get the data from the database, which is displayed on the client browser eventually through the resolution of XML and rendering of RS.

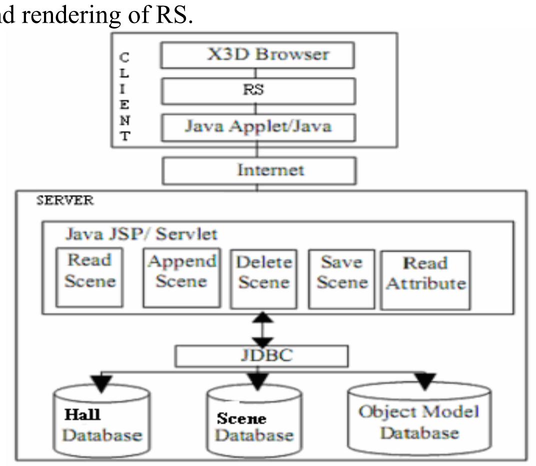

Figure 1. The framework of the system

2.1Rending sub-system (RS)

The main function of rendering sub-system (RS) is to render the 3D scene and model effectively at the client. Actually, we developed a real-time rendering plug-in which could be embedded in the browser based on a source-open software----X3DToolkit [10]. In detail, the functions of RS include reading and converting X3D/VRML files, the organization of X3D/VRML scene and model, converting X3D/VRML scene and model into certain kind of scene OpenGL supports. What's more, several fast graphics-rendering algorithms, such as cutting Culling, LOD, and so forth are employed in RS.

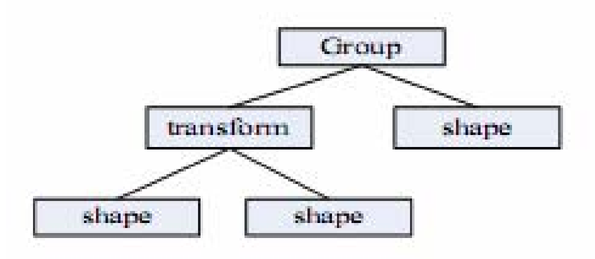

Figure 2. The classic scene organization

The organization of scene graph plays an important role in RS. The typical X3D scene graph is showed in Figure 2. In order to render scene and model, we should read the X3D files from remote server and translate them into X3D scene format. In RS, we adopted Web3D [5] standard specification to finish the VRML, X3D/XML and binary's encoding reading and translation.

To realize the scene rendered at the client, we need to translate X3D scene into GL scene OpenGL supports. Based on BSP and Portal technologies, we (fulfill the organization of 3D interactive and indoor scene, which can solve the problem of indoor scene's management and scheduling. The basic function of BSP tree is to divide all the polygons in the scene into smaller sets. Meanwhile, we must ensure that each set is a convex set. During the establishment of the BSP tree we must ensure the structure of the tree is a balance tree. After the establishment of the BSP tree, we can travel all nodes in the scene conveniently such that it is easy to render and make collision detection.

2.2 Interaction with 3D scene and model

Interaction with the scene and model means client users can handle the virtual 3D scene and model. For instance, users can walk in the virtual scene, open the door, change the model's color, texture and perspective, open the model and watch the internal detailed structure of the model and so forth.

Interactive effect can be achieved by the X3D's own nodes. For example, combination of the PositionInterpolator, TimeSensor and TouchSensor can obtain an object's movement interaction and the effect is that the object starts to move after clicking it [11]. However, this kind of interaction generating from X3D's own nodes is simple and dull, just as uniform motion or rotation and color change and so on. This unitary animation control results in some limitation of function of "relatively static-like Behavior Animation". Because user's logic can't control the animation after it starts. So the logic used to control the scene can only be outside of X3D scene.

Generally, we can use the Java, JavaScript and ECMAScript to support logical control in the X3D scene and model. Take the ship lock of Three Gorges Dam as an example, Code shown as follows:

3.SYSTEM IMPLEMENTATION

This software is developed on Windows XP/2000 operating system and using Microsoft SQL Server 2000 database server to build a database system and server is Tomcat 6.0. Front and back of the sub-systems using MVC framework, which is Jsp+Sevlet+JavaBean to be developed and the development tool is MyEclipse6.0, the Rendering Sub-system developed on Visual C++ 6.0.

The client is a user-oriented home page. Users can overlook the huge dam in long distance as Figure 3 shown. Users can overlook ship-lock of the huge dam as Figure 4 shown.

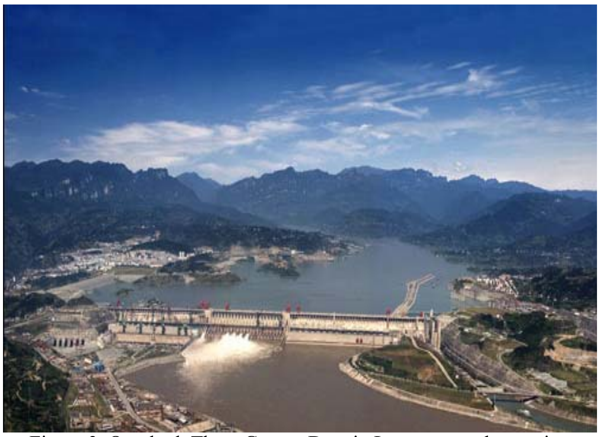

Figure 3. Overlook Three Gorges Dam in Long-range observation

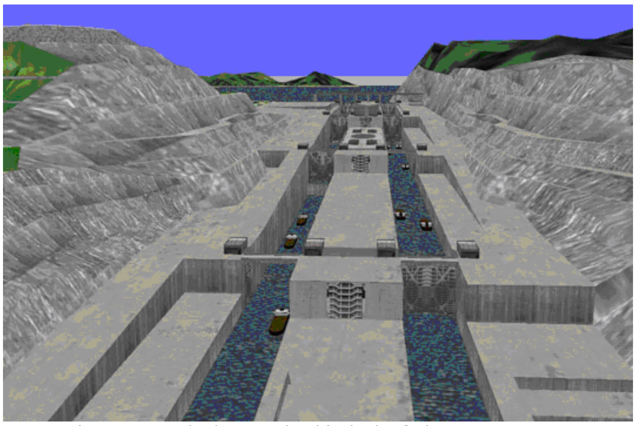

Figure 4. Overlook Cascade Ship-lock of Three Gorges Dam

Using Virtual Reality in this context offers a wide range of possibilities. The virtual user or visitor can navigate freely on the scene, climb a tower of a non longer existent dam, fly over the main building and visualize it from above. If accurate reconstruction is embraced, this virtual user can even walk close to a ship-lock.

Accurate 3D representations of that period were not available until this work began. Modeling this data and later visualizing it using Virtual Reality techniques expands the possibilities for water heritage understanding. These techniques can extend our perceptive capacity and make interaction between numeric simulations and experimentally gathered data possible. Various tools are used to help the reconstruction process and to assist the developer to visualize how they think a building or place looked, was used, has developed and changed etc. Currently these tools are most often drawings and sketches, knowledge of similar places still standing, photos, etc. The need for a collaboration environment for two different teams, with different technological backgrounds also pushed the development and usage of open standards for 3D communication and production. There was a need for a tool that could satisfy both sides.

Three phases (data gathering, modeling and visualization) of the working process.

3.1Data Gathering Process

This initial phase of data gathering took approximately 10 weeks. However, during the next phase, we discovered that, in order to accurately model some of the buildings, more data should be researched and gathered. Although this research phase accomplished almost its objectives completely, it actually extended itself through out the project due to the constant re-evaluation of the 3D modeling and requirements for data to fulfill missing spots in the modeling.

The database of Three Gorges Dam consists of over 10,000 plants and microfilms. Because we need more precise information of the huge dam to reconstruction.. We had to setup a capturing device for taking high-resolution pictures with 10 mega pixels.

3.2Modeling Process

The modeling phase consisted of carefully analyzing the data collected and distributing them to expert modelers. Our goal was to accurately depict the Dam as it really looked. The experience should be complete, fulfilling the immersiveness required for VR Environments.

The design and review process was an extenuating phase where every week the experts would analyze and compare our models to the actual buildings data collected, in order to certify the 3D models. But we could not always count on regular on-site visits to discuss the design process. This limitation could have imposed a constrain on the workflow productivity if we have not used the X3D standard to publish our weekly results on a website. This situation saved a lot of trips to Three Gorges Dam and vice versa, which alternatively would not have been done, delaying our project goals.

The process saved a lot of time: instead of creating high definition renders and the time consuming lighting process, theX3D files provided an easy and accessible alternative to the design process of our work. With this web-page setup, the specialists were able to interactively analyze our work from the comfort of their offices. The possibility provided an interactive visualization that greatly improved the analysis process.

The software Maya from Autodesk [13] was used to model the environment. It provided a uniform platform for modeling and rendering visual prototypes with enough accuracy for analysis. Maya does not natively supports exportation to the X3D format standard. However we were able to use an open source Maya exporter called Rawkee [12]. The export phase was not successfully achieved at the beginning due to problems in the Rawkee exportation. Texture coordinates and normals would get mixed up in the process, affecting the overall look of the model. This had to be manually corrected using the X3D-Edit tool. Another approach that reduced the time-consuming design review process was the utilization of the X3D standard.

3.3Interactive VisualizationProcess

Using our in house visualization software, we were able to visualize the modeled data in an immersive Virtual Realityenvironment. Our visualization tool was designed to run on VRClusters [14] and also to support the X3D standard.

The scenegraph plays an important hole in VR visualization tools. This layer is responsible for organizing the whole scene in a hierarchical and optimized way, causing the overall performance of the application to be increased. The scenegraph is the only layer of the visualization application that is aware of the hierarchy of the scene, and its parameters as well. Building a scenegraph from scratch was not under the scope of our project. In fact, there are a handful of initiatives that deals with this issue. We analyzed several of them including OpenSG, OpenSceneGraph, Coin3D and Ogre3D, taking into account their characteristics in the following aspects: object oriented approach and design, easy programmability learning curve, platform independent and most important, overall performance for rendering high fidelity models, with millions of polygons and high quality textures and shades.

Although all these libraries are very well implemented and are plenty of resources for optimization, unfortunately, almost all of them lacks in documentation, making available only a few source codes as examples. The Ogre3D was chosen because, besides of having all the necessary characteristics and desired features, it also has a fairly good documentation and a lot of tutorials for beginners and advanced users.

Although Ogre3D supports many 3D file formats, one of particular interest to us is not yet supported: X3D. Given our usage and experience in the previous phase, we wanted to maintain this format as a default for our visualization tool. We needed to develop a custom data loader from X3D to the Ogre3D scenegraph structure.

4. DISCUSSION AND CONCLUSION

In this paper, X3D is applied in 3D virtual experience system. A plug-in embedded in browser is developed for graphical management and rendering, which is implemented at the client. With X3D's own nodes and external JavaScript, a kind of friendly interaction with model and scene for user is achieved.

The models were periodically published so that the specialists could analyze them and provided feedback in the form of reports. There was no annotation tool in the X3D website nor the X3D browser supported it, so the reports where written and sent back using another convenient type of document.

One of the most important things in this project was the level of close collaboration needed, which certainly pushed our efforts into organizing a design review process that were interactive and at the same time productive.

We also encountered some conflicts through out the project. In process like this, the content creation (3D reconstruction) is based on incomplete information, leading to dubious representation and interpretation of the available data. The constant exchange of ideas and discussion of both teams permitted a rapid identification of problems thus leading to a rapid search for a solution. Moreover, the Virtual Reality team opened their minds to other aspects and concerns that non-experienced users have when using such technologies, which will improve future projects.

5.ACKNOWLEDGMENT

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