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A Centralized Web3D for Archiving and Viewing Cultural Artifacts Based on WebGL Technology

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***Abstract*—This paper proposes the prototype of a centralized system for archiving and viewing cultural artifacts in 3D based on WebGL technology. The objectives of this project are providing a platform to integrate data from different museums and providing services for both cultural experts and public entities to visualize artifacts in 3D. The prototype include three parts, which are Producer side, Server side, and Consumer side. In addition, the result of the system could enable the exchange of knowledge and experience between people in their societies.**

***Keywords*—Web3D, WebGL, computer 3D graphic, 3D cultural artifact**

I. Introduction

Cultural artifacts are a part of cultural heritage which is an important part of any society since its history is defined by the same and by the surrounding population. Cultural artifacts have been an integral part of the everyday lives of human beings in the past as well as in the present times. In preserving and taking care of them, museums have an important role to play as they are involved in collecting, preserving, interpreting, and publishing information related to the same to the community. However, of late, physical museums are facing many problems such as insufficient space for collecting and displaying cultural artifacts and new demands from new audiences in the digital society that the world has become, with its fast changes and technological pushes which can facilitate achieving data via the Internet networking. While the digital world has been growing and changing rapidly over the past few years, various technologies have been developed that are able to convert data from analogue to the digital format. These technologies are good tools for digitizing cultural artifacts from real objects to 3D objects. Therefore, digitizing the huge collection of cultural artifacts around the globe is a real challenge. This is because the 3D cultural artifact modeling can avoid the direct damages over time, as well as the effects caused by natural disasters or even human behaviors. Furthermore, the presence of people and organizations on the Internet is rapidly growing. Hence, for serving new demands from the audiences in the Internet society, a centralized online system of 3D cultural artifacts needs to be created. However, even in the present times, there is a dearth of central repositories of 3D models for preserving cultural heritage data. Many scientists still have a problem with doing so much documentation for preserving the world's heritage resources and conserving their own digital products. Koller et al. (2009) points out: "There is no tool to discover whether a particular cultural artifact has been digitally captured or modeled; even a Google or Yahoo search is generally fruitless, and there is no Web resource specifically in this area"[1]. In the end, the end-users, such as cultural experts, students, or members of the general public, have no means of accessing authentic 3D cultural artifacts. It is true that online resources are able to offer a wide range of high quality scientific 3D digital models of cultural artifacts usable for further study. Additionally, because of new technology such as WebGL 3D graphic API, it is now possible to develop complex computational environments including 3D graphics directly using the Web browser. Finally, with the rationale and the possibilities of technology, as mentioned above, it should be possible to develop a 3D cultural heritage center for collecting and sharing cultural knowledge on the Web3D.

II. Literature Review

A. *Cultural Heritage and Cultural Artifact*

UNESCO (1972) defines cultural heritage of world value as "architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science" [2] (see Figure 1). And, a "cultural artifact" can be defined as a small object that is produced or shaped by human craft, especially a tool, weapon, or ornament of archaeological and historical interest, that is significant to the culture of a community [3] (see Figure 2).

Figure 1. Examples of cultural heritage structures and art forms.

Figure 2: Examples of cultural artifacts.

B. *3D Virtual Cultural Heritage*

3D Virtual Cultural Heritage is the knowledge that analyzes the data studied by archaeologists and historians of art and architecture. These data include three-dimensional objects such as works of art, pottery, and cultural artifacts. There are three ways in which digital tools support this kind of data: (1) representation 3D capture with laser scanning, (2) modeling by hand with 3D software, and (3) making hybrids (models and capture) [1]. In the past, as mentioned in the report on the Annual Conference of Computer and Quantitative Methods in Archaeology in 1985, Leo Biek presented an article of stereo-video. After 1990, the professional organizations around the world started to show a keen interest in virtual heritage. The Association for Computing Machinery (ACM) began sponsoring the publication of the new journal devoted to the field, which is called the Journal on Computing and Cultural Heritage, in 2007. In the next decade, as 3D modeling software and data capture systems began to be mastered and their prices began to fall, some have been made free. For example, Google provides SketchUp for free 3D data capture.

C. *3D Computer Graphic*

3D Computer Graphics has become interesting an interesting field of study and application the world over because it can represent the complex information of certain artifacts (see Figure 3). 3D modeling is used in environmental design and is applied in many technical and scientific fields — for example, in medical imaging techniques (which give physicians a "more real" look inside the body) and in the study of artifacts in that cultural heritage 3D models can protect and study history [4].

Figure 3. A complex elephant-shaped candle holder suitable for representation by 3D modeling.

D. *WebGL*

WebGL demonstrates high performance in displaying and viewing 3D objects by using JavaScript engines. In addition, the WebGL has shown many interesting variations in creating new generation techniques for new Web applications. The WebGL accesses the Graphic Processing Unit (GPU) by using JavaScript language to present high-quality 3D graphics directly on the Web browser for viewing text, pictures, and movie clips. For using WebGL technology, there is no need to install any additional software or plug in to view 3D in front of the Web browser. WebGL is a cross-platform, royalty-free Web standard for low-level 3D graphics that are API based on OpenGL ES 2.0 and exposed through the HTML5 Canvas element as Document Object Model interfaces. A WebGL JavaScript application is defined entirely within an HTML document that is loaded into a Web browser. In principle, all that a Web designer needs is a text editor to write WebGL statements. The WebGL interface takes care of the communication with the client's graphics hardware through OpenGL libraries. The full power of the underlying graphics hardware is, thus, harnessed by WebGL for quality user experience [5].

E. *WebGL Mid-Level API*

WebGL mid-level API is a JavaScript library that will make it easier to write 3D applications using WebGL. It provides a set of math, scene, and 3D object classes which makes WebGL more accessible for developers that want to develop 3D content in browsers but do not want to have to deal in depth with the 3D math needed to make it work. Figure 4. shows an example of the WebGL libraries that provide for developers to avoid the low-level work with difficult logical concepts to develop 3D on the Web [6]. The concept of this model can be described as follows:

- UI: user interface and 3D operations to allow speedy and easy setup of the Web page with 3D viewports.
- ASYNC: asynchronous content to load the object for transfer notice to enhance the asynchronous loading 3D model.
- MESH: 3D model definition and rendering.
- MATH: linear algebra objects and functions work as a base tool to reduce the complexity of the mathematical part for the computer graphic programmers.
- GL: graphic library for the Web developers to access WebGL.
- VISUAL: special effects to support color, camera, lighting, texture, mouse moment, and other visual components.

Figure 4: An example of WebGL libraries.

At the time of writing, fourteen WebGL mid-level APIs had been developed including C3DL, Curve3D, CubicVR 3D, Copperlicht, GLGE, KUDA, O3D, OSG.JS, PhiloGL, SceneJS, SpiderGL, TDL, Three.js, and X3DOM. Table 1 shows the comparison between the available APIs.

TABLE I. ARRANGEMENT COMPARISON OF DIFFERENT WEBGL MID-LEVEL APIS

API	Focus on	AUX. Tool
C3DL	Game, Interactive, Animation	Math, scene, and 3D object classes
Three.js	**Game, Interactive, Visualization**	**Camera, Core, Lights, Loaders, Materials, Math, Objects, Renderers, Scenes, Textures, Animation, Geometries, Fogs, Skinning, Shadow maps, Alpha tests, and Even morphing**
X3DOM	Modeling, Visualization, Animation	Environmental effects, Interpolations, Lighting, Rendering, Shaders, Sounds, Volume rendering, Textures, Geospatial tools, and Networking
SpiderGL	Visualization	Material Editor, Lighting, rendering
NetGL	Visualization	Scene Editor, Shader Editor, Profiler, Lighting

Three.js is a WebGL middle API that this project chose to develop the prototype because Three.js has many materials for support, such as textures, fogs, skinning, shadow maps, alpha tests, and even morphing. Additional (specialized) materials are lambert, phong, normal, depth, and face material. There is also a shader material and a material for particles as well. The lighting part includes the following: ambient, directional, point, and spot lights. For the purpose of Web3D archiving and viewing cultural artifacts, Three.js is the appropriate candidate to develop a 3D Web platform.

F. *3D Objects Preparation*

Figure 5. Preparing the 3D contents and viewing the models by using WebGL.

Figure 5. shows that the development tools used in preparing 3D models for WebGL can be of various types such as Google SketchUp, 3D Max Studio, and 3D scanner. For simple models with low polygon, it is better to use 3D software. For complicated models with many polygons, it is better to use 3D scanners for better results and better models. For using a 3D scanner to digitize cultural artifacts, the producer is required to have experience in 3D technology in order to understand the know-how of developing the 3D model. Before using the 3D scanner, the producer needs to learn how to use a 3D scanner and use the appropriate software for the best results. Therefore, it is imperative that the producer understands what file format support is required for WebGL technology in order to view the 3D model in the browser. In the course of testing and developing, choosing a 3D file format is a most important decision. This is because there are many different ways of storing data and supporting hosts of features. Hence, archiving and viewing 3D cultural artifacts on Web platforms using WebGL should be done by selecting the most suitable 3D file type. Wavefront OBJ format is the appropriate format to use with 3D cultural artifacts. OBJ file format is open, simple to use, and compatible with the WebGL technology. At present, 3D software provides an option to export 3D to OBJ format; it also provides the facility to import to different 3D software, such as Google SketchUp and Autodesk 3D Max. The OBJ file format is optimized for the concept of developing a 3D presentation and has elements as follows:

- File structure/General statement
- Vertex data
- Specifying free-form curves/surfaces
- Free-form curve/surface attributes
- Elements
- Free-form curve/surface body statements
- Connectivity between free-form surfaces
- Grouping/Display/render attributes
- Comments
- Mathematics for free-form curves/surfaces
- Superseded statements
- Patches and free-form surfaces

III. System Design

A. *System Overview*

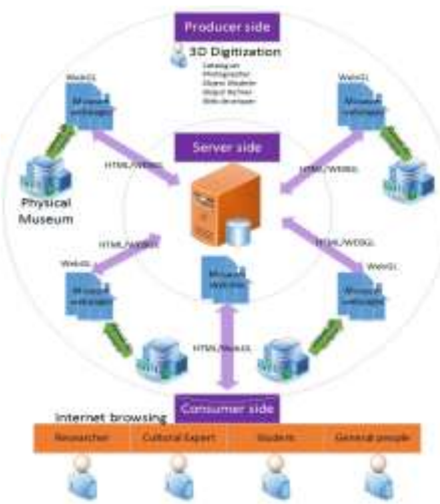

Figure 6. An overview of the platform.

The conceptual framework is shown in Figure 6. The model includes three essential modules: consumer side, server side, and producer side. *Consumer side* includes researchers, cultural experts, and general people who are interested in the field of cultural heritage. They can get access to the contents through the typical Web browsers and allow users to access 3D collections from museums around the world from a single portal. *Server side* is the corporation between Content Management System and WebGL mid-level API. The system is operated by a Web browser that provides view-based search and browsing services to the end-users. *Producer side is* the personnel in the museums who digitize 3D cultural artifacts with metadata, based on their technical knowledge and skills, and upload them to the centralized system.

B. *System Architecture*

The methodology, divided into three main parts, which enables the users to interact with the data, is shown in Figure 7.

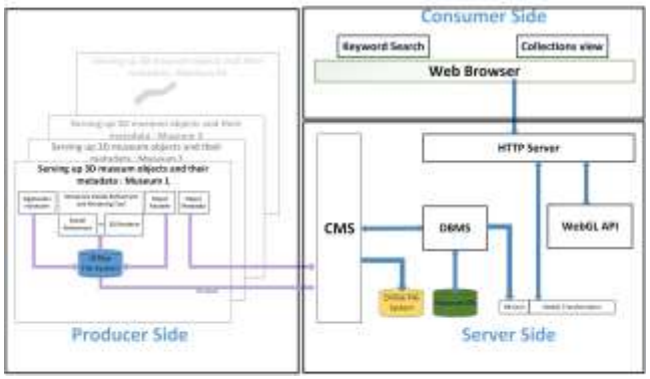

Figure 7. The architecture of the system.

The process of each flow summary is as follows.

- Consumer side is responsible for preparing dynamic presentations to be displayed on the Web browser. The features include advanced search, WebGL renderer functions. Visitors can use the former to simply search and browse the database contents.

- Server side is responsible for storing and organizing Database Management System (DBMS), authoring with PHP and MySQL. The WebGL middle API is provided for transforming the 3D object to the consumer side section, which is given in the next step. Additionally, this part includes Content Management System (CMS) to manage content for front end and backend such as user account, file categories, etc.

- Producer side is responsible for creating 3D content. The process of digitizing 3D objects is done using 3D scanners, and the refinement of the object is performed with 3D software such as Sketch UP, 3D max, Blender, or Maya, which is then exported to the object format file. After completing the digitization of the 3D objects, the object file is uploaded to the system along with the database and the associated metadata.

C. *Data Set Management*

In this section, the method of uploading file .OBJ and Textual files to the file system and database record for indexing with WebGL functions is demonstrated.

WebGL Archiving 3D Objects

```
// Loader
var loader = new THREE.OBJLoader();
loader.load( "3dobjectfile.obj", function ( object )
   ……
```

WebGL load texture for the model with THREE.ImageUtils.loadTexture

```
//Texture
Var texture =
THREE.ImageUtils.loadTexture('textures/texturefile.jpg');
```

WebGL Viewing 3D Objects

```
// Renderer
renderer = new THREE.WebGLRenderer();
renderer.setSize( window.innerWidth,
window.innerHeight );
……
}
```

IV. Results and Discussion

In Centralized Web3D Archiving and Viewing Cultural Artifacts implemented using WebGL technology, the results obtained in the producer side and in the consumer side are the following:

Producer side: The museum as the producer can register on the Website by creating their account and inputting the details of their museum. After that, they can upload their 3D artifacts file to the system along with the database and the associated metadata.

Consumer side: Researchers, cultural experts, students, or general people as the consumer can browse and search the 3D artifacts from the Website and can view the cultural artifacts in 3D on the Web browser.

With the development of Web3D, consumers can easily obtain information regarding artifact models on Web browsers. Consumers can use a keyboard and a mouse to rotate and zoom the artifacts.

To obtain the best results, and correctness and accuracy of the 3D cultural artifacts, as far as the real size, shape, and actuality of the models are concerned, it is necessary to be experienced in using 3D scanners and in being able to understand how to use the 3D scanner software properly. It is necessary to spend time on scanning the models and removing the noise of the 3D scanner software. In addition to the extra amounts of time needed in developing this prototype, the 3D scanner is quite expensive, and it might be a sensible option for developers to choose a 3D scanner on the basis of their work requirement.

V. Conclusion and Future Works

The final result for this project is that a centralized 3D cultural heritage archive on the online system can give rise to long-term objectives and planning for many museums in the world, such as plans for collection, reviewing, publication, updating, preservation, and sharing of 3D objects. It is a prototype system that can provide the archiving and viewing of 3D cultural artifact on a Web platform by using WebGL technology. WebGL can be adopted by curators and cultural experts all over the world for cultural learning and for transferring cultural knowledge. The three main advantages of this prototype system are its ease of use, high automation, and quickness that makes it particularly appropriate in cases where huge collections have to be processed in a fast-paced manner. This system has extremely important benefits for the Cultural Heritage field. Nevertheless, this field still needs complete, automatic, and combined tools for the digital archiving and viewing of 3D cultural artifacts on a Web platform. Our further aim is to provide an editor for developers and users to upload and edit 3D models in the system, and to provide new 3D channels to learn and share 3D artifacts by using semantic Web technology in order to improve the performance and better the optimizations for 3D cultural artifacts.

Acknowledgment

The results show 3D cultural artifacts with good quality of 3D viewing. In addition, it does not take much time to load the 3D model by using the .OBJ file format even if the file size is bigger than 2 or 3 megabytes. For good and fast-loading 3D objects, the system environment is of utmost importance, and so it is highly desirable that the system environment at the client’s end is complete with high CPU processing, good amount of RAM, and GPU Card in order to render 3D using the WebGL technology. **The recommendation for the system environment is that it should have the following criteria: Intel Core i5 @ 3.2 GHz or above, 4GB DDR3 RAM, GPU Device -NVIDIA GTX 465**. The browsers are Firefox 4.0 or above, Google Chrome 11 or above, Safari OSX 10.6 or above, and Opera 12 or above.

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