

3D Environment for Virtual Collections

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Abstract. This paper describes a framework for building virtual collections of several digital objects and presenting them in an interactive 3D environment, rendered in a web browser. Using that environment, the website visitor can examine a given collection from a first-person perspective by walking around and inspecting each object in detail by viewing it from any angle. The rendering and visualization of the models is done solely by the web browser with the use of HTML5 and the Three.js JavaScript library, without any additional requirements.

Keywords: 3D, Web Browser, Virtual Museum

1 Introduction

With the emerging Internet technologies, there is an increasing demand for interactive websites in all areas that use the online medium. This is especially valid for digital libraries, e-Learning and other information and presentation-critical fields. Today's audience is expecting new and interesting ways for presenting the cultural, historical, archaeological and other objects [2]. If those are not provided, the interest in these fields will decrease. Providing new alternatives for exploring museum exhibitions like displaying collections of 3D objects and building such 3D environments are the ideal tools for attracting more viewers. These virtual environments also resemble the virtual worlds existing in computer games to some extent, making them highly appreciated by children. This is very important if we want to make the younger generation culturally aware so they can preserve our historical heritage, and we need to show them a new, more exciting way of exploring the cultural collections of our past.

In a recent research [1], we presented a plugin which allows 3D objects to be easily displayed and rotated in a web browser supporting HTML5, without having to worry about all the complex mathematical calculations required for that task. The online presentation of 3D models of cultural and historic artifacts is a modern alternative to using 2D images and videos, which are crucial formats in fields like digital libraries and e-Learning. The combination of several artifacts into one collection, displaying them together and allowing the viewer to freely move between the objects and view them from any angle, is a significant step toward the goal of having a virtual museum.

In this article we will present a framework for building and exploring a three-dimensional environment comprised of a collection of digital objects. That environ-

ment allows the author to select a set of 3D models to be displayed on a stage, by setting up configuration options such as their position, scaling, lightning, historical details, and so on. After being composed, the scene can be viewed as a web page, allowing visitors to explore all artifacts inside it, from all different aspects. They are able to freely move the point of view and change the direction they are looking at, which will make them feel like they are in the actual room and are walking among real objects located inside. The visitors are also able to examine each object's information supplied by the author, which completes their experience and need for knowledge of the specific collection.

The system we developed is suitable not only for the end-users - the viewers, who want to "visit" and explore a virtual collection, but is also useful to authors who would want to prepare a collection of digital items and present that heritage to the general public, or more specific groups of people like students, tourists, etc. The freedom to choose and combine objects of all kinds into a virtual collection gives the content creators the option to generate the right content for any specific event and target group. This article presents one use of modern web development technologies, which makes museum exhibitions a new and exciting online adventure, while preserving the real artifacts. In the next section we discuss the motivations for developing and demands for such an environment. Part three describes the details around the core component of the framework used for rendering the 3D scene containing the virtual collection. In the last section we talk about future work, plans for extending the research and improving the functionality of the presented framework.

2 Increasing Demand for Virtualization in Museums

Developers have expanded their research and development of virtual museums during the past ten years. The various initiatives for digitalization of physical libraries are making clear that they should be applied to museums as well. The characteristics of real museums listed below, considered disadvantages for modern people, are making the need for frameworks for building virtual museum more pressing. The contemporary museums:

- Are showing real physical objects and this requires time, space and staff to make the setting, as well as facilities for storing and preserving the artifacts.
- Some objects require special conditions or maintenance for their proper preservation.
- If objects are too fragile, expensive, incomplete or missing, they cannot be displayed to the general public.

All of the disadvantages mentioned above show the need for a system with which authors can create virtual collections and present them in an online format over the Internet. In paper [4], the authors point out that traditional presentation materials such as text and images are not enough for describing the objects' properties, purpose and relations to other objects. In most cases, especially where physical access to the real artifact is not possible, an additional three-dimensional view of the digital object is

needed. Authors of digital content can prepare 3D models of the objects in their collections by using methods like scanning real material objects, reconstructing lost cultural heritage using authoring tools to develop the model like 3D Studio Max [5], or building three-dimensional models from a set of images. Once prepared, the digital artifacts need an environment to be rendered and shown to the general public, and ideally such an environment will display more than one object at once, present object-related information in a rich text, sound and other formats, and allow the viewers to freely observe anything they want in any order (as shown in fig. 1).



Fig. 1. Virtual collection of several objects

In our effort to meet those requirements, we have developed a framework for building virtual collections of several digital objects and presenting them in a 3D environment, to be rendered in a web browser. In order to use the developed environment, the author needs to have a collection of the objects in a popular 3D formats, which he wants to be displayed. The author can then define the position of each object in the digital room, its description and other details to be displayed, properties like scaling, rotation, and etc. The framework itself takes care of all the calculations, rendering, lightning, controls, requiring the user only to describe the properties of each object in a specific format, revealed in the next section. The objects need to be saved in one of the most popular formats, although the majority of three-dimensional model formats can be converted to any other, using 3D authoring software such as 3D Studio Max or Maya. Figure 1 above shows a collection of several medieval objects being displayed with our framework.

The 3D environment we developed can also be used by all people having Internet access, to explore pre-created virtual collections from a first-person perspective by moving between the objects and observing them from all angles – this can be seen on figure 2. Another targeted group of users include the museum organizations, which will be able to prepare virtual collections for tourists, specific to their interest, or show objects that are in very poor condition or even missing. Furthermore the museums could take advantage of such demonstrations and place them on their website, attracting more visitors to come and see the real exhibitions.



Fig. 2. Exploring an object from the collection

3 Rendering 3D Collections

An essential part of the developed 3D environment is the rendering component, responsible for visualizing a predefined set of objects (artifacts) and allowing the user to move between and observe them from any angle. We implemented this framework in pure JavaScript, in order to make it executable on all modern web browsers, as well as to support all desktop and mobile devices and platforms. We chose the Three.js open-source JavaScript library [6] for leveraging the complex rendering tasks, which internally uses the HTML5 canvas element and its WebGL rendering context interfaces.

The rendering component is packaged as a class expecting the entire configuration related to the collection being rendered, as a parameter in its constructor. The configuration options are described in JSON format and include the ID of the HTML element which will hold the canvas element, rendering the 3D graphics, and a list of dictionaries, describing various properties for each object in the collection, such as name, description, model file location, position, rotation, scaling, etc. After initializing the component, the only thing that remains to be done is to start animating it, which will take care of all the rendering and updating of the three-dimensional scene.

The base 3D components, which we use for creating the virtual room and displaying a set of objects inside it, are:

- A scene to which we add all the camera, lights and objects;
- A camera, positioned somewhere in the 3D space and pointing at some direction;
- Lightning sources for making the objects visible;
- The objects, each one defined by a model and an optional texture, as well as position, and other properties;
- A renderer, drawing the scene based on the current camera position.

The first thing our component does is to initialize the 3D scene, to which we later add all the other elements like camera, lightning sources and models. The second step is defining the camera, which the renderer object will use for rendering. The camera object defines how wide the field of view is, the aspect ratio, and the minimum and

maximum distances from objects to be rendered. The camera also has a position in the scene and a direction to which it is pointing, and these properties are defining the perspective from which the user is viewing the scene. We use a perspective camera type for rendering our scene, because it makes it more realistic - the perspective projection [7] is showing the distant objects smaller and the closer objects bigger. The perspective camera provided by Three.js also handles the changes of window size much better than any other camera type.

The lightning effects we have used in our scene include two directional lights in two opposite corners of the room. Directional lights are comprised of parallel light rays originating from infinitely far away and affecting everything in the scene, like the sun in the real world. Those lights require the smallest amount of rendering computations in the three-dimensional world. In order to illuminate all sides of the objects however, we include two directional lightning sources pointing in different directions.

The 3D models of the artifacts in the virtual collection being presented are the main focus in the scene. We developed our code to support one popular format initially - OBJ, which allows an optional material and a texture to be supplied with each object. However, because Three.js can load three-dimensional models in a variety of other formats like Collada, PLY, STL and others, we could easily extend our rendering component to support one of those popular formats. The models' properties are specified in a list of JSON dictionaries, describing each object's name and description, to be used when showing the additional information provided for each artifact in the room. The object properties also include the characteristics of the 3D model being imported in the scene - its type (e.g. obj), location of the model file and the location to an optional material file. Last, the properties must describe each object's position in the scene in three-dimensional coordinates, optional rotation of each of the three object's axes, optional scaling for each of the three axes, and the dimensions and position of a base, on which an object can be placed if needed.

The last of the building blocks of the rendering component is the Three.js renderer object. The renderer makes all the complex 3D calculations and draws the scene based on the properties of all geometries inside it like objects, lights and cameras. The fastest renderer provided by Three.js is the WebGLRenderer, because it has access to the devices' hardware acceleration through the WebGL context of the HTML5 canvas element [1], making graphics processing extremely fast. The only downside of that type of renderer is that not all of the web browsers support it. However, most of the contemporary web browsers implement the WebGL canvas context and even if we want full support, we could still change the code to fall back to a slower, but available renderer. Apart from drawing the complete 3D scene that contains the virtual collection, our rendering component also handles the user's keyboard and mouse input, which are used for controlling the movement between the objects and the free look of the camera. The camera's position is moved along the X and Z axes (back and forth, left and right) using the arrow or WASD keys. The camera's direction is changed by moving the mouse while holding the right button. Those kinds of controls are very similar to the ones in computer games, and are ideal for first-person 3D environments like ours.

4 Conclusion and Future Work

In this article we presented the reasons for building a 3D environment for displaying a collection of objects online. The various reasons circulate around the need of presenting the digitalized cultural heritage on the Internet in a more realistic and attractive way. In our attempt to solve that problem, we developed a JavaScript framework allowing authors to choose a set of three-dimensional models of artifacts or other cultural objects, and display that collection in a 3D scene online. To view the collection, the users only need to open its webpage using a standard web browser, and start exploring it from a first-person perspective using the keyboard and mouse. By providing the ability to walk between objects and observe each one in detail the environment we implemented brings a more exciting and fresh experience to the audience.

The framework we introduced in this paper can be used in many scenarios, related to 3D object presentation into a virtual scene. Our plans for future development include extending the environment with an authoring module GUI, which will provide to content creators an easier way to build virtual collections and setup the properties of each object, previewing their changes on the moment. Another important module for such a system would be an Access Control component, which will allow authors to share a virtual collection only with specific people, as well as assign certain permissions to them. Such permissions can include for example the ability to edit the collection, delete it, and change the group of people that can view it. The rendering component we described thoroughly in this paper could be improved by adding sound and other presentation materials like an embedded story-telling component, visualizing the information related to each object in the collection. Furthermore, the system could be enhanced to support some kind of a social interaction between its users, allowing them to see each other, communicate and exchange information about virtual and real world events.

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