

# A Web Application for Creating and Presenting 3D Object Expositions

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**Abstract.** This paper describes a recently-developed web application for creating and presenting expositions of three-dimensional objects online. The system allows authors to create exhibitions of 3D models and share them on the Internet, where everybody will be able to view them. The latest HTML5 technologies allow the use of modern web browsers to render the 3D collections without any additional requirements, such as installing third party plugins, which makes the system easily accessible for users operating on different environments.

**Keywords:** 3D Rendering in the Web Browser, Online Exhibitions, HTML5.

## 1 Introduction

During the last couple of years web browsers have increased their support for HTML5, allowing web developers to implement complex UI tasks like 3D rendering. The latest versions of modern browsers now fully support hardware acceleration through the WebGL context of the canvas element [1], which makes 3D rendering possible with no need for installing additional software. Even though this technology is mainly used in computer games, the need for virtual environments is emerging in other fields such as digital libraries and e-Learning, where alternative ways of online presentation are required. The demand in those fields is driven by many goals including capturing the attention of the younger generation to make them more involved, employing more interactive environments, having the freedom to combine all kinds of objects, with different dimensions, origin and age, otherwise physically impossible to be combined in reality [2].

Visualization of digital cultural artifacts has been performed by using 2D images for many years. Online resources like informational web pages and interactive tourist guides have been delivering two-dimensional images of the related content, and in very few cases individual 3D objects were displayed in a Flash animation or part of a PDF document. These implementations have a lot of drawbacks – the images do not offer the ability to view an object from different perspectives, the other solutions require the installation of a 3rd party software on the user's computers, the inability to visually compare two or more objects by putting and viewing them together. To meet those challenges, developers have started using the latest additions to the HTML5

specification – the canvas element and its ability to render 3D scenes containing multiple models, lights, terrains, and other artifacts, in the web browser.

Several major frameworks exist for abstracting the complex tasks of 3D rendering and allow the developers to focus on the functional requirements of their applications. In their paper [3], the authors describe how they are using the Unity3D library for building a virtual tour around a Russian medieval fortress, viewable in a web browser. Virtual Art Space [6] is a website that offers artists the ability to create online exhibitions and present them in virtual galleries where visitors can view them and interact with each other. The free version allows authors to upload only images that are shown as paintings but there is a paid version that allows the addition of 3D statues, special coloring options, audio tour and other extras. Virtual Art Space was also built using Unity3D and thus requires the installation of the Unity Web Player software on each computer it is viewed from. In this paper we will discuss another popular framework – ThreeJS, which we used for developing the solution described here.

As part of a previous research [4], we developed a component for visualizing collections of three-dimensional models of real-world objects in an interactive 3D environment. Built with HTML5 and the ThreeJS JavaScript library, the component allowed users to examine the exhibitions assembled in advance, only with their web browsers. We have further extended that framework and created a complete web application for authoring and presenting 3D object expositions [5], which we describe in this paper. The presented application is a full-featured web environment offering complete collection management functionalities to the authors - creation, publishing, editing and deletion. From a password-protected section, the authors can access their dashboard and administer the collections they own. Non-registered users have access only to the public areas of the website like the list of most-recently published collections, each published collection and other application-related content. Authors can create expositions containing either only one object, such as a building or a car, or add multiple objects intended to be viewed as part of one collection. We have extended the rendering component and allowed the authors to specify different configurations for their collections and each object inside them, such as various details, floor texture, object position, scaling and base.

In the next section we will discuss the most important characteristics and functionalities of the system. Part three reveals the technical details behind our implementation including the frameworks and approaches we chose. In the last section we talk about the future work and planned additions and improvements of the presented software.

## **2 A Complete Authoring Environment**

The web application we created is a multi-user system imposing different access restrictions and showing different parts of the user interface based on the current user's roles. There are three groups of users in the system - administrator, author and everybody else. Whenever a visitor arrives at the home page [5], the list of most recently created and published expositions is displayed, and clicking on a thumbnail will lead

them to the exhibition visualization area, described in the next paragraph. The application's homepage and a sample view of an exposition are shown in Figure 1 and Figure 2. The top menu, which is always shown, allows users to quickly navigate between different areas of the application. It is also dynamically updated to display additional items based on the current user's roles and permissions – for example, it will render a link to the management screen for authors and administrators.

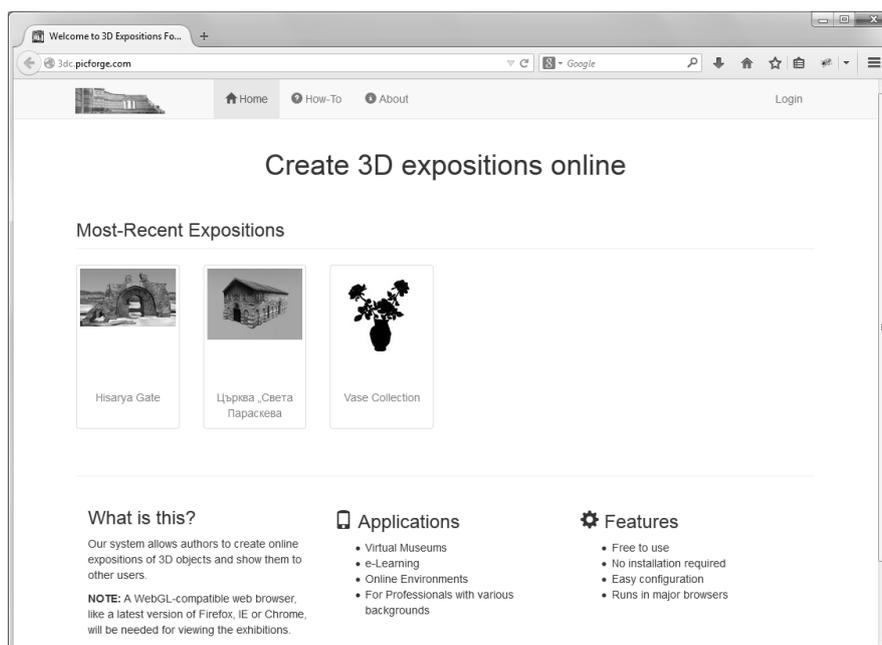
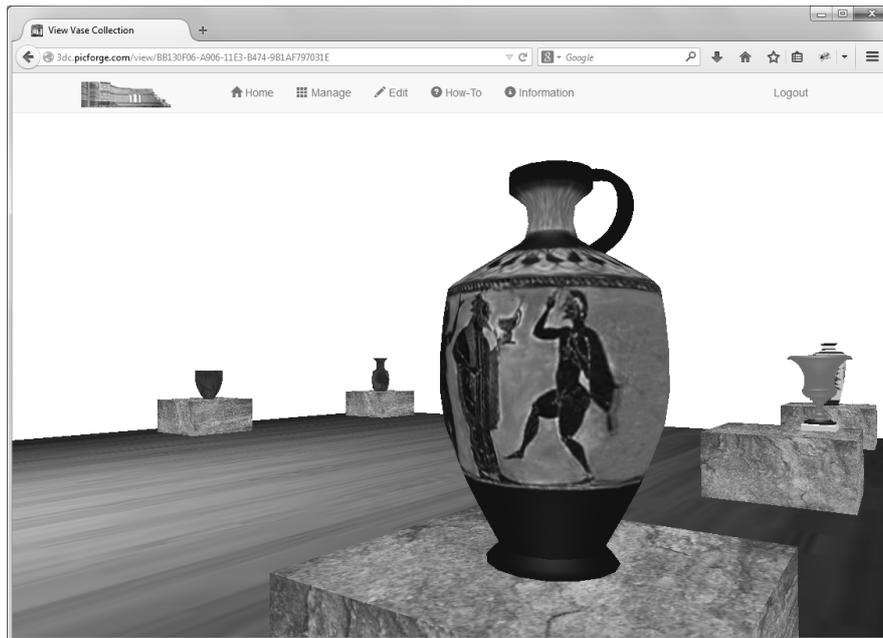


Fig. 1. The application's homepage showing the most-recently created expositions

An inherent part of the application is the exposition rendering component, responsible for visualizing the collections of 3D models and allowing the user to freely move between them using the keyboard and changing the look using the mouse. Given a pre-configured exposition with one or more objects inside it, the rendering component initializes a 3D scene, containing the necessary assets such as cameras, lightning sources, the object models, and other geometries and textures for the floor and bases for the objects. After the rendering process has started, the user is able to change the position of the camera in the three-dimensional space with the keyboard, simulating movement in the scene, as well as change the direction the camera is pointing at, using the mouse. The controls allowing these moves are common for every computer game and this makes the user experience very smooth and friendly. The resulting three-dimensional environment is very realistic because the viewer can control her movements and choose what to explore at any given moment. The additional information about individual objects or the whole collection is shown in popup windows, outside of the 3D scene. When the user clicks on the Information button on the top menu, or the base block under an object in the exhibition, a popup window containing

the title and description properties of the item is displayed. Those messages can easily be dismissed using the ESC key or by closing them explicitly with the mouse. If the current user is the exposition's author or an administrator, an additional top menu link for editing it will be shown.

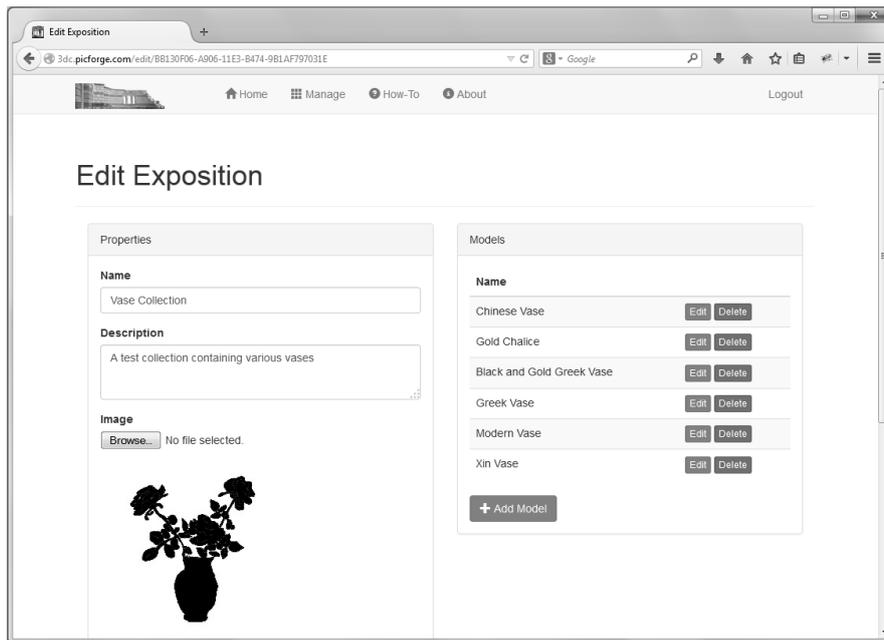


**Fig. 2.** Viewing an exposition by freely moving around objects

The authors in the system are registered users having that role associated with their accounts. After successfully logging in, a Manage link appears in the top menu, which when clicked will lead them to their exposition management dashboard. From that area, authors can see a list of expositions they own and create new ones, view, publish, unpublish, delete and open for editing already created ones.

The Edit Exposition section, illustrated in Figure 3 below, is used by authors to specify the properties of their expositions and the objects part of them. For each exhibition, owners can specify its name and description, a thumbnail image and the type of floor texture. The floor can currently be set to one of the three options – Wood, Grass and Stone, and by changing that option authors can refine the setting of their exhibition. Depending on their specific needs, like what objects are being displayed and what the target audience is, creators can control whether everything is arranged on a wooden or a marble floor, or a field of grass. In addition to these settings, the Edit Exposition screen allows authors to add, edit and delete 3D models of objects in the current exhibition. The 3D models being uploaded are required to be in the OBJ format and all model files like geometry, material and texture files, should be packaged in a ZIP archive. After an object is added, the author can update its name, description, scale, distance from ground and base. The scale property is useful when the

original object is too small or too big, and its size needs to be changed for the purpose of the exhibition it is part of. The distance from ground property allows the objects to be placed on any height on the scene. The base property controls whether the object should be standing on a marble block or directly placed on the ground. Having a base will improve the presentation of smaller objects such as pottery, and is not needed for larger objects such as big statues or buildings.



**Fig. 3.** Exposition authoring page

The third group of users - site administrators, have access to every part of the system and can manage all exhibitions in the system, including those created by other users.

### **3 Using Latest Web Development Technologies**

For implementing the server-side of our web application, we chose the Perl Catalyst Framework. It is a Model-View-Controller (MVC) framework that provides many components like template engine, database models, authentication and authorization, and RESTful API controllers out of the box. Because the volume and usage of the system is relatively small in this initial phase, we deployed it using an SQLite database backend, but when the load gets higher in the future we could easily migrate it to an enterprise database management system due to the detached architecture provided by Catalyst's MVC support. The application is run by Plack – a web application server for Perl, where we configured several middleware components for caching and request throttling as prevention mechanisms against unintended use of the system.

The entry point of the system is an Nginx web server, serving static content, such as images, CSS and JavaScript files directly, and proxying the other requests to be handled by the Plack instance of our application.

In addition to the end-user functionalities provided by the web interface, the system also provides a set of RESTful web services for manipulating its entities. Any third-party software, like a web browser or another application, can use the API to get all published expositions, retrieve information about, update, publish, unpublish and delete a certain exposition, and etc. These web services allow the functionality of our application to be fully integrated with any other software and used in many different scenarios. The restricted requests such as deleting and updating a certain collection, or trying to view a non-published one, require authentication, so unauthorized clients will not be able to access these resources.

The user interface is conforming to the HTML5 standard and depends on its full support by the client devices. The exposition rendering component mentioned previously requires that the WebGL context for the canvas element is supported by the web browser. Currently the newest versions of Internet Explorer, Firefox and Chrome support that, so using one of them is the only requirement to view an exposition. To perform 3D rendering, the ThreeJS JavaScript library is used. It provides support for cameras, lightning sources, models and other facilities used in 3D rendering, removing the need for the developer to do any complex calculation tasks. The rest of the application's user interface is built with Bootstrap, jQuery and ShieldUI frameworks. Bootstrap is a powerful CSS/HTML5 front-end framework for web page layout, which is fully responsive – i.e. web pages look good on all kinds of devices and resolutions – desktops, tablets and mobile. We use the jQuery JavaScript library for general DOM manipulation and event handling, like handling keyboard and mouse interactions to move around and rotate the camera while viewing an exposition. We have also integrated ShieldUI JavaScript framework to add custom UI widgets, such as charts, grids and loading panels, which are not traditional HTML components and would not be available otherwise.

From an architectural standpoint, there are virtually no limitations for using the system – it is designed to scale and support high loads. However, depending on the user's hardware configuration, a decrease in performance of the rendering component can be seen. This is why we have limited the maximum number of objects in an exhibition to nine, and the maximum OBJ file archive to be uploaded to 2MB. A suggested configuration for a single object's 3D model would be several thousand vertices, which will ensure fast load and smooth rendering (more than 20 frames per second).

## **4 Conclusions and Future Work**

The general-purpose 3D exposition management system we created is a unique environment for creating and sharing exhibitions of three-dimensional objects online. Because having a latest version of a web browser is its only requirement, it can be accessed from all kinds of browsers and devices. Thanks to the wide range of functionalities the system provides, authors can cover any specific scenario for their expo-

sitions – from showing one big object such as the model of a car or a building, to a collection of multiple smaller ones. Using common keyboard and mouse keys, viewers of an exposition can interact with the environment and control their movement around it, thus choosing what specific object to examine and from what side, at any time. Additional text information can be retrieved for an object or the whole collection and will be shown in a popup window. The system is suitable for a wide range of scenarios, including but not limited to e-Learning, virtual museums and digital libraries. Besides through its user interface [5], the application's functionality can also be accessed via the REST web services it exposes. Using those web services one can integrate the exposition management or the rendering sections in another web application. Using recent web development technologies, we designed the system as a cloud application, making it extremely scalable and capable of handling high loads.

The next steps for improving the environment are to extend the metadata currently being stored for each object. In addition to the title and description of each entity, we will add other characteristics like author, origin, dates, and other properties, inspired by the Dublin Core Metadata Initiative. This effort will be accompanied by updating the corresponding HTML pages and web services to include the objects' description in RDF, so they can be properly consumed by the respective agents and other software. Another important feature which is currently missing is the search component. Once we extend the metadata, we will add a search page and a web service, providing the ability to find certain objects, expositions and authors in the system.

The authors in our environment could benefit from having more flexible access-control mechanisms, allowing them to share expositions with a certain user or a group of users only. Another common scenario is several authors to be able to manage the same set of expositions. By introducing such component, we will allow creators and owners to apply more clear rules about their exhibitions, preserving their intellectual property and making it accessible only to the right group of users.

There are a lot of other items on the wish list of application functionalities. Improving the rendering component to allow more interactivity, adding social media sharing and real person connection capabilities are just a few points on that agenda. Extensions for the authoring section, such as support for other 3D model formats and a utility to optimize 3D models to a form, more suitable to be viewed in a web browser, are also important. By completing those goals we are not only providing a unique environment to the community, but also ensuring that their requirements will be fully realized.

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