Presentation Layer in a Virtual Museum for Cultural Heritage Artefacts

Desislava Paneva-Marinova[0000-0001-5998-687X], Maxim Goynov,
Detelin Luchev[0000-0003-0926-5796], Lubomir Zlatkov

Institute of Mathematics and Informatics, Bulgarian Academy of Sciences,
Sofia, Bulgaria
dessi@cc.bas.bg, goynov@gmail.com,
dml@math.bas.bg, lyubcho@gmail.com

Abstract. This paper aims to show the presentation layer of a virtual museum for cultural heritage artefacts. The three-dimensional representation and the main components of a 3D environment of the virtual museum are discussed. The composing 3D objects in the virtual museum, with different viewing options, as well as an implementation of a three-dimensional representation and the means for greater realism of the three-dimensional image, are described

Keywords: Virtual Museum, Presentation Layer, Cultural Heritage, 3D Objects, Three-dimensional Representation.

1 Introduction

Digital technologies introduce new solutions for museums, galleries and libraries, concerning the documentation, maintenance and distribution of the huge amounts of collected material. Virtual museums already have proven their worth as a contemporary conceptual solution for access to and attractive presentation of cultural archives. The term and the concept of the virtual museum (VM) were created in the early 1990s, but both are still under development (Schweibenz, 2019). Some authors (for example: Skamantzari, Georgopoulos, 2016) continue to use the W. Schweibenz's (2004) definition for VM as "…a logically related collection of digital objects composed in a variety of media which, because of its capacity to provide connectedness and various points of access, lends itself to transcending traditional methods of communicating and interacting with visitors…". As a working definition in projects the term "virtual museum" is accepted as "a digital entity that draws on the characteristics of a museum, in order to complement, enhance, or augment the museum through personalization, interactivity, user experience and richness of content" (Virtual Multimodal Museum, 2018). Virtual museums contain diverse collections of digital objects (such as text, images, and media objects) that are organized in various ways and are managed by complex specialized services. The management of digital content requires a well-designed architecture that

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embeds services for content presentation, content management, administration of user data and analysis. Virtual museum design issues, system architecture, functionalities and models for intelligent data curation are analised (Paneva-Marinova, Stoikov, Pavlova, Luchev, 2019).

The ideas of combining virtual reality (VR) and captured reality (CR - accepted as the exact virtual 3D reconstruction of a real object), have a strong influence on the development of virtual museums of cultural heritage (Pietroni, Adami. 2014; Jiménez Fernández-Palacios, Morabito, Remondino, 2017; Carvajal, Morita, Bilmes, 2020). The integration of VR and CR creates virtual tours with elements and artefacts from the real-life museum(s).

This paper aims to show the presentation layer of a virtual museum for cultural heritage artefacts. Section 2 of the paper presents three-dimensional representation and the main components of a 3D environment of a virtual museum for cultural heritage artefacts. Section 3 includes a discussion on a panoramic photo, taken from a real-life place (museum), and composing 3D objects in a virtual museum with different viewing options. In section 4, an implementation of a three-dimensional representation and the means for greater realism of the three-dimensional image are described.

2 Three-dimensional Representation. The Main Components of a 3D Environment

Just like movie scene, the virtual 3D scene consists of lights, objects, camera(s), camera controllers. The process of projecting a 3D scene through the desired camera(s) into a 2D screen (the user device display) is called rendering. The engine responsible for this task is called a renderer. The renderer is also responsible for different picture effects, color management, tone mapping, etc.

Very important and critical part for the 3D rendering and performance is the complexity of the scene. In order to have good performance on any device (even older devices with mid-ranged graphic cards) we need to keep some acceptable level of complexity for our scene – the museum room. One of the main resource consuming factors in a 3D scene is the number of polygons used to present the 3D objects. That’s why we have created an optimization process for each museum object.

When a 3D object is created using a 3D scanner, or manually from a 2D picture, or using other techniques, including AI, it may contain a large number of polygons. In our example the object is not a complex one, so we have created it from a 2D picture (Fig. 2) using path tracing, extrusion on the Z coordinate and some very simple sculpting (in terms of 3D). For our purposes we use the 3D software Blender.

Fig. 1. The original 2D picture

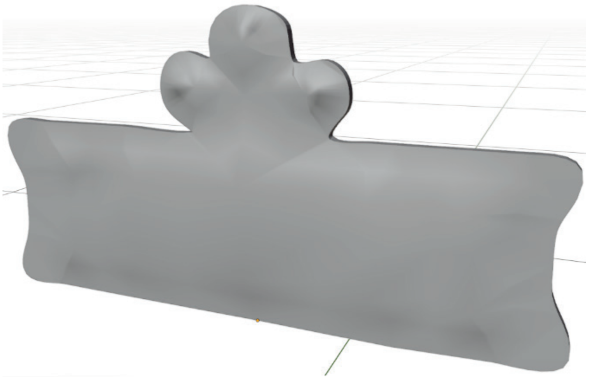

Fig. 2. A simple 3D model, created from the given 2D picture

Even though the produced model (Fig. 2) is simple, it still has polygons which may be reduced. We achieve this using the Limited Dissolve algorithm of Blender. The number of polygons is reduced from 3076 to 466 (see Fig. 3), which will lead to a significant performance improvement.

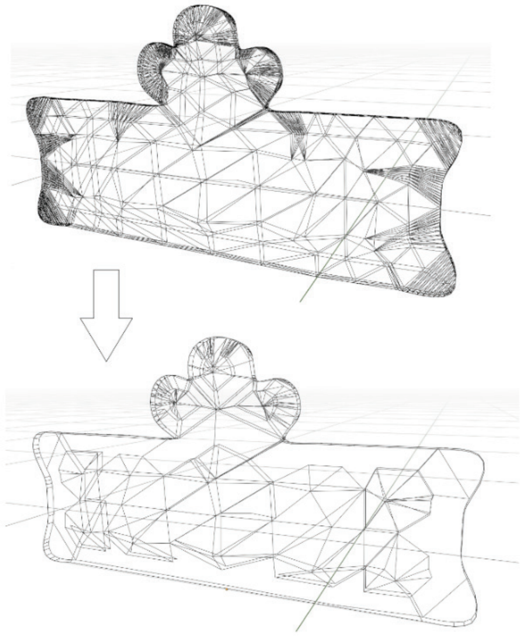

Fig. 3. Object simplification (reducing number of polygons)

The next step is to apply a diffuse map and a normal map. The purpose of the diffuse map is to define the colors of the objects, strictly speaking – the way the surface of the objects reflects the light. In our case we will use the source 2D picture. The only thing we need to create is the so-called UV map (see Fig. 4) which defines the position of each polygon of the 3D object on the diffuse (or normal) map:

Fig. 4. UV mapping

At this step the 3D object appearance is almost completed:

Fig. 5. 3D object with applied diffuse map and proper UV mapping

One more improvement is achieved by using the normal map (Fig. 6) – more detailed 3D objects without the addition of more polygons, resulting in an improved performance, while keeping relatively good quality of our 3D objects.

Fig. 6. A normal map (RGB coded coordinates)

A normal map is a RGB bitmap where every color (RGB – red, green, blue) is assigned to a coordinate in a 3D space (XYZ). So, for every pixel in this bitmap we have a vector representing how the light intensity on that specific point should be changed when rendered. Usually, normal maps are created using algorithm analyzing the differences between the high poly object (usually taken from 3D scanner) and the low poly optimized object (Mikkelsen, 2008). In our example there is no high poly object, so we used a tool which helps us to create normal map using just a 2D picture: https://cpetry.github.io/NormalMap-Online/.

The final result when the normal map is applied looks like this:

Fig. 7. 3D object with applied normal map and advanced lighting

3 Panoramic Photo from a Real Place (Museum) and Composing 3D Objects in It with Different Options for Viewing Them

One of the points to be concerned when creating a 3D virtual scene is the scene background, i.e., the surrounding environment. It can contain 3D objects and/or a flat scene background picture. In our example we used a panorama picture in equirectangular format (Snyder, 1993):

Fig. 8. Equirectangular picture of the museum room

The panorama picture was taken from a museum room in the Burgas Regional Museum, Bulgaria.

The main disadvantage of the panorama picture used for the main scene surrounding is that this picture is flat, and because it is taken from just one point, the scene camera should not move from that point in order not to distort the background projection. That's why in this scenario the camera can only perform zoom in/out and rotate around the main point:

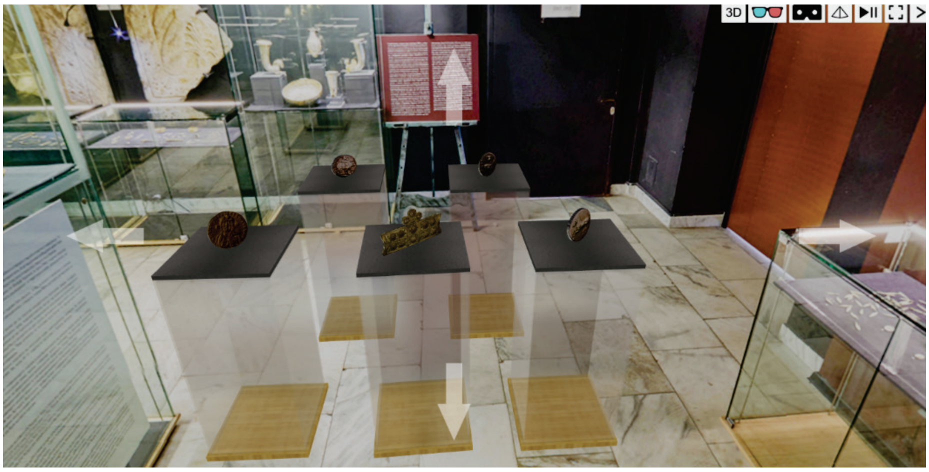

Fig. 9. Rotation of the scene camera

Fig. 10. Zoom in/out of the scene camera

4 Implementation of Realizations of Three-dimensional Representation and Means for Greater Realism of the Three-dimensional Image

Different technologies for creating more vital and immersive 3D experience exist. Many of them are used in 3D cinemas and home theatres. But all of them are based on the concept for presenting two different pictures for each eye. This method is called stereoscopy (Banks, Read, Allison, & Watt, 2012). In a real 3D scene this is implemented using the so-called stereo camera – actually these are two cameras pointing at one direction just like the human eyes. The distance between the cameras is fixed and also represents some average value between the left and right human eye. For the stereoscopic version of the virtual museum, we have chosen those technologies which do not require expensive and complicated equipment and are suitable for home or school use:

- Anaglyph 3D (see Fig. 11). Anaglyph is a method in which two pictures are presented on one place. The pictures are filtered with cyan and red filters, so the viewer needs anaglyph glasses (with red filter for the left eye and cyan filter for the right eye) to see the scene properly and to feel the depth of the objects (Helmut, & Fritz 2006). The disadvantage of this technology is that the colour saturation gets reduced.

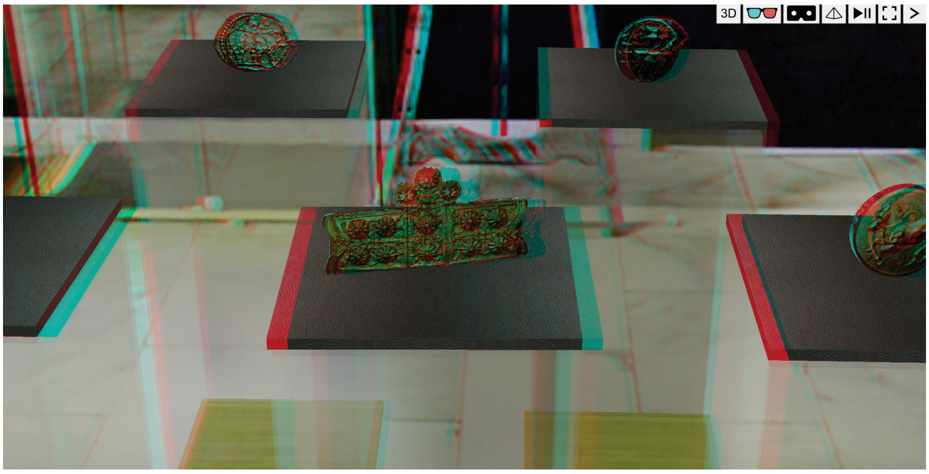

Fig. 11. Stereoscopy. Anaglyph 3D

- Virtual Reality (VR), (Fig. 12). This method presents the two pictures – one to another. Special glasses called VR glasses (or VR cardboard) are needed to view properly the scene, which is projected usually on a mobile phone device screen. Here, the colour saturation is fine and the 3D presentation is very realistic. The overall effect is boosted by the mobile phone device orientation sensors (accelerometer and/or gyroscope) which are used to rotate the 3D scene camera around the base point, while the viewer moves around with the VR glasses (Bozorgi, & Lischer-Katz, 2020).

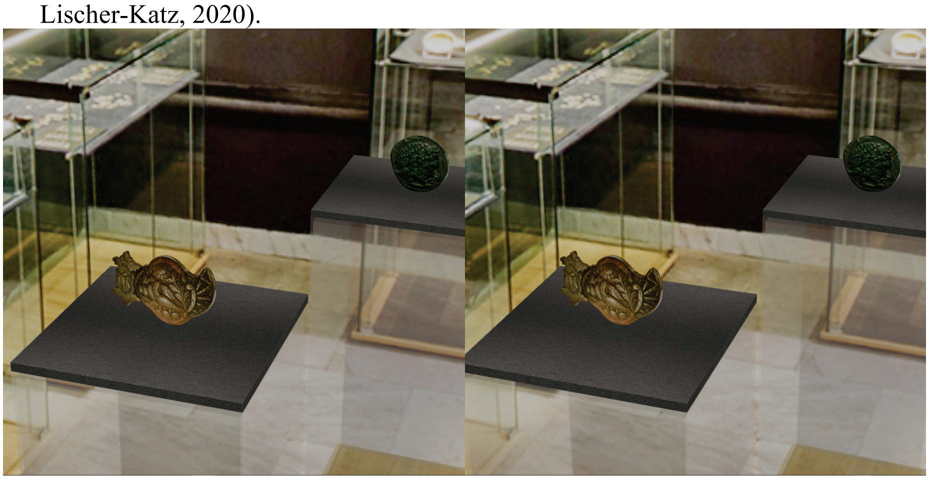

Fig. 12. Stereoscopy. Virtual reality view

- Holographical pyramid. Another interesting and impressive way for presenting a 3D object is the holographical pyramid (a.k.a. fake hologram). It is not a real hologram, but the effect is similar. The object is presented on a display (mobile phone, tablet or some other horizontally positioned display) recorded from four different points (front, right, back, left), (see Fig 13). A pyramid created from half transparent reflective material is placed at the center of the display (Fig 14). As a result, the object can be viewed from a 360-degree perspective.

Fig. 13. A tablet presenting the four sides of an object

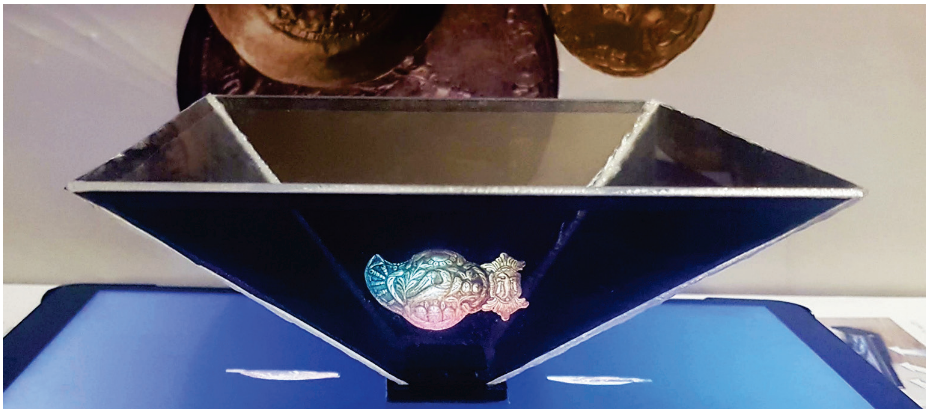

Fig. 14. A holographic pyramid placed on the tablet

A working example of the demo room can be found here:
https://demo.bg73.net/3d/museum.html.

5 Conclusion

A virtual museum implementation has a set of important factors in order to become usable, convenient and to be responsive to the user experience. In a modern web environment, concepts like multiplatform systems and responsive designs are must-haves. Platforms should be optimized in order to consume less resources (CPU, GPU, network load) while keeping great performance and content quality. Finding new ways for content presentation is not just a trend, but is very important for the users to have more realistic depiction of the artefacts presented, especially in the cases where the access to the physical objects is limited or impossible. As a future development of the presented work, we will concentrate on eliminating the panorama pictures as 3D environment background and switching to a more complex real 3D modelled environments where users will have more options for their virtual walks – they will be able to explore every point of a virtual scene that looks much more authentic.

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CAQQAw&url=http%3A%2F%2Fimage.diku.dk%2Fprojects%2Fmedia%2Fmorten.mikkelsen.08.pdf&usg=AOvVaw39xZIoqelhDtbU6wJBrcAz. [Accessed 7/6/2021].
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