

A configurable design approach for virtual museums

C. Tsita, A. Sinanis, N. Dimitriou, K. Papachristou, A. Karageorgopoulou, A. Drosou, and D. Tzouvaras

Information Technologies Institute - Centre for Research & Technology Hellas, Greece

Abstract

Virtual Museums (VM) are widely used to preserve and to disseminate cultural heritage to the audience, due to the existing evidence that they can enhance the interest on cultural heritage content, while reinforcing motivation for a real museum visit. A variety of technologies are being used including Virtual Reality (VR), to display cultural heritage objects (CHOs) and related information, in order to offer enjoyable and immersive experiences to the visitors. Additionally, educational aspects of VMs are being explored, due to their inheritance from physical museums, which are educational institutions, among their other roles. Innovative approaches such as authoring tools for the creation of VMs have been introduced in order to fulfil the variant needs of field specialist, audience and educators. The diversity of contexts where a VM can be used, require the creation of open access tools to form customizable VMs for every need. This study aims to present a configurable design approach for the creation of VR museums. The goal is to disseminate the virtual artefacts and introduce them in an appealing way to the audience, the field experts and conservators, through VR experiences. The current version of the VM, allows the curators to dynamically insert objects in the virtual space along with their metadata and measurements derived from various scanning processes. The proposed design approach can support the structure of an open access platform for the creation of immersive VM exhibitions.

CCS Concepts

•Applied computing → Arts and humanities; •Computing methodologies → Graphics systems and interfaces;

1. Introduction

During the last decades, VMs have increasingly been used by real museums as they can be effective means to increase the museum visits. Furthermore, VMs can promote cultural content in ways that are not possible to be used in physical museums, adding educational and entertaining values to the museum experience, as well as to disseminate cultural content that can not be displayed in a physical museum or it is not widely accessible. Additionally, a VM can bring together virtual objects from different museums and places around the world, in order to provide unique museum experiences [SKP*14] [ViM18]. Having in mind that physical and virtual museums share the commitment to institutional validation of content and experience through curatorial process [ViM18], VMs research contributes to both: in enhancing VM's users experience and support VM's curators' work. The first comes with the use of different technologies to improve visualization of virtual spaces and rigorous representation of cultural heritage objects (CHOs), while the second aspect comes with authoring tools and flexible system structures that allow the users to create VMs content, with different accessibility and interactivity levels [SLKP09] [SKP*14] [BBM17]. A VM may be a representation of existing collections or exhibitions, or may exist independently being exclusively digital, while the exhibition may be organized around specific CHOs [AR17] or they can be formed to host content from other external sources [KKP16]. The level of detail, the representation, as well as the in-

teractivity level of a VM varies according to its primary goals. In this paper, the proposed VM is presented as an experimental prototype, that introduces new ways on managing and displaying CHOs. Various CHOs have been scanned with different sensors, resulting in different kinds of measurement data, which are related to the CHOs. The data are being displayed to the conservators and the interested public with an immersive and attractive way. Additionally, a VM management tool, allow the users to insert CHOs from a database to the VM and manage their position inside different rooms. The rest of the paper is structured as follows. Next section provides a short review on related work and the contribution of this study. The second section presents the motivation of this study, while in the third section the suggested management tool is described. The VM is presented in the following sections. Finally, the last section presents the conclusions of the study and the upcoming work.

2. Related work and contribution

In recent years, numerous VMs have been created, some of which aroused from generic systems that allow users to create their own virtual exhibitions and cultural content. The ARCO project [WMD*04] provides a system for museums to create, manage and display artefacts in virtual exhibitions. Through a Management Application the user stores, manages and organizes the virtual artefacts into collections, while can browse virtual exhibitions via web

and Augmented Reality (AR) environments. The DynaMus framework [KKP16] exploits the cultural content which is already on well-known web repositories for the creation of interactive virtual exhibitions. By emphasizing on user-friendly authoring processes, the DynaMus framework gives the possibility to the users to create a VM without technical skills required. The visitors can create and edit their own spaces, as well as to browse other users' exhibitions. Both, 2D and 3D assets can be exhibited. 3D Publish tool [SA12] allows the curators to insert and manage artefacts and their relative information, as well as define visit scenarios for the exhibitions. The users, from the other hand, can visit the exhibition freely or by following the pre-defined scenarios. In [KMP12] the user can freely navigate through the virtual exhibitions to view the objects closer and rotate them at the spot. An interesting feature is that the visitor can additionally update the content of the exhibition by submitting query questions. iMuse [FFTB14] focusing on communicating the cultural heritage content, allows the museum personnel to prepare multimedia presentations about artefacts, which visitors can access either on site or via web. In the Antikythera mechanism VR VM [AR17], the user is allowed to grab and rotate the fragments displayed. Additionally, the visitor can view the fragments in X-ray mode, which provide visual information about the inner layers of the fragments, revealing the hidden formation of mechanism's gears. Overall, the transition from dedicated VMs to flexible VMs accompanied with authoring tools has resulted to the creation of different platforms and applications that focus in different aspects. The intention of the proposed VM is to provide a holistic framework for the digitization of CHOs, their documentation in terms of their material and structure status, and their dissemination, with easy to use and immersive 3D environments, through web and Virtual Reality technologies.

3. Motivation

The main objective of the proposed VM is to enhance the accessibility of the digitized CHOs to the scientific community, the field experts and the general public. The end-users of the proposed system, classified to curators, restorers and conservation scientists, provided their needs regarding the overall system. Additionally, the general public requirements were gathered by people in charge of museums and collections. The goal was to find a holistic solution that can help the visualization of all the surfaces of CHOs and of all the material and stratigraphic information. A VM would provide access to the aforementioned information via web, but also fill the gap between the traditional way of display and the need for innovative ways to facilitate the experience of the object. The VM would not replace the physical visit but rather supporting it by making the experience broader. To this direction, the proposed VM would offer a user-friendly managing system that is realized via direct interconnection of the VM's platform with a dedicated database. The VM setting would facilitate the CHOs' accessibility and dissemination along with their relevant data. Finally, the VM would not be a representation of a real museum, but a 3D virtual space, which incorporates typical physical museum characteristics.

4. Virtual museum management

The management tool allows the curators to insert CHOs in the VM. The curator runs the management application to view the VM

rooms. By selecting one of the available rooms, the user can view its floor plan (Figure 1). Thereafter, the curator clicks on a spot on the floor map and selects one of the CHOs included in the database, in order to insert it in the selected area. The CHO is imported to the VM with the corresponding metadata, measurement points and measurement results. The management output includes the selected CHO, along with the corresponding information (metadata, measurements etc.) and the position and size user inputs. The VM application parses the CHOs xml files and displays the corresponding 3D models in the VM, with the selected scale and position values (Figure 2).

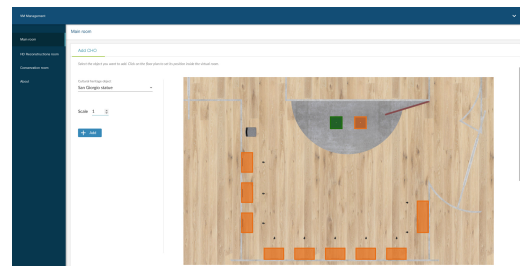


Figure 1: The manager application interface

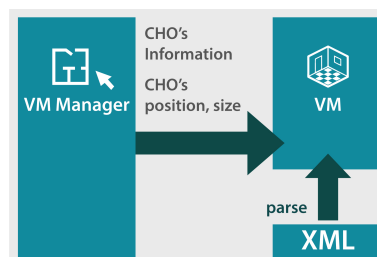


Figure 2: The management tool connected to the VM

4.1. XML format

In order to organize all the above information in a structured way, an XML-based format has been designed for using a single XML file as reference. More specifically, the proposed XML Format describes the set of elements which define the content and structure of XML documents for storing all the information related to a CHO consisting of metadata information, recorded data by various sensors and related modules' output (3D reconstruction, simulation, annotation). In more detail, the root element of an XML file document based on this XML format is the *CulturalHeritageObject* element, that:

- may have zero or more children *Metadata* elements which includes a piece of metadata information about the object's history, content, characteristics, etc. It consists of the name of field, its value and optionally an illustrative description of the field,
- must have one child *GlobalScanning* element to represent global 3D scanning of the object acquired by an RGB-Depth sensor or a visual photogrammetry camera,
- may have one child *LocalScanning* element to describe local recordings/measurements (2D images, plots) acquired by an IR camera, Ultrasonic sensor, UvVis, Raman and FTIR spectrometer, XRF, RTI and Profilometer sensor,

- may have one child *Reconstruction* element to represent 3D reconstructions (coarse and high resolution) of the CHO,
- may have one child *AgeingSimulation* element to include ageing simulation results that enable users to investigate an object's state at different time instants (i.e. texture modeling, geometry modeling, surface modeling), and
- may have one or more children *Annotation* elements to store annotation results (e.g., degradation types, material, time).

5. VM web and desktop editions

The VM has been implemented with Unity game engine and is accessible online, where the user can run the web edition; download the desktop or the VR Oculus rift edition, that are available for multiple operating systems. Three thematic exhibitions have been formed, in order to be used as prototypes to explore the CHO's dissemination and the VM configuration possibilities: the Main room, the HD Reconstructions room and the Conservation room (Figure 3). The VM rooms were created in external software and then imported in Unity engine. The content of the VM was defined with the management tool. These rooms exhibit 3D representations of CHOs, along with measurements resulted from different scanning techniques. Additionally, some CHOs are related to images that represent the ageing of CHOs material, derived from simulation techniques, allowing the user to view the CHOs in different time instances.

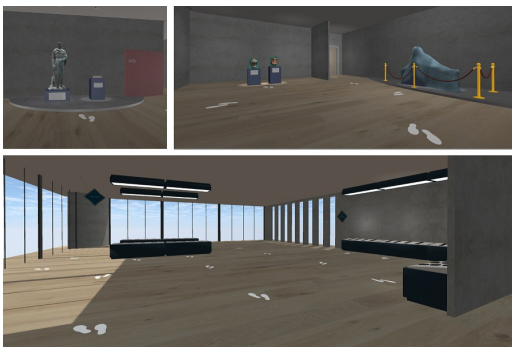


Figure 3: (a) Main room, (b) HD Reconstructions room, (c) Conservation room

The main room exhibition displays four objects, while the HD Reconstructions room hosts two CHOs. The VM supports the documentation of materials commonly used in art, through the integration of reference samples of such materials in the Conservation room. The actual panels have been artificially aged in ageing chambers and after each ageing round measurements of the material have been performed and documented in the an online open access database [SCA15]. The images of the panels' measurements were used as textures of the virtual objects. Three room areas have been formed according to the samples material: "Bronze", "Silver", and "Egg Tempera".

Initially, aiming to explore how it would be possible to create any VM by combining room and exhibit flexible entities, some typologies of museum rooms were created. Following the design principles mainly derived from physical museums characteristics, the room typologies were defined to host pedestals and paintings,

accompanied by their spot lights. In order to explore expandability possibilities of the VM, the 3D room models, were used independently in the game engine, as separate scenes. Additionally, the passes among the rooms were defined by doors. Having in mind that all of the rooms have the same 3D model for the doors, any room can be visually received as the expansion of any other, while the user has the same reference point when enters or exits a room. In case of future expansion of the VM management tool, additional to the CHO itself, the user should be able to select room typology, as well as exhibits (along with lights) typologies to define the virtual spaces. Additionally, the user should have the possibility to delete or edit existing rooms and expand the VM with additional rooms.

In order to transit to another room, the user clicks on the door and selects to transit to any other room of the VM. These options are also available in the main menu allowing the user start from any room. Thus, the visitor can navigate around the museum without restrictions regarding the sequence. The user can form their one path inside the museum, exceeding the limitations that a physical space would have, without excluding the linear option.

6. VR (Oculus rift) edition

The VR edition offers a realistic immersive experience of the VM for both Oculus and pc users. The natural aspect of the experience is stressed by the use of colliders and collision detection to set the bounds of every object. The height of the user is also taken into account providing the corresponding perspective view. Moreover, the use of volumetric sounds, photorealism and physically-based-rendering (PBR) materials also contribute to a more realistic environment of the scenes. The suggested navigation method is teleportation, however the user can also traverse the museum either with FPM (first-person movement) or teleportation to fixed points (Figure 4). In order to assist the navigation a minimap is provided with marked points of interest. The user interacts with a reticle which is guided by the HMD's (Head-Mounted Display) focal point and allows the user to know what is targeted at any given time. Interaction feedback is given to the user through a loading bar, when she selects an interactive item. Moreover, the user has access to a menu that provides several options to parameterize and enhance the VR experience. The application also supports users that have no oculus rift equipment by falling back to FPM mouse-driven movement and concentrating most of the controls onto the mouse. When the user enters the application, a tutorial scene is available. The VR room that hosts the tutorial represents the entrance of the museum and contains a sample CHO (Figure 5) and its data. In the tutorial the user is asked to complete a set of tasks, that require VR controls and showcase the capabilities of the application. For each task the user receives guidance and hints in the form of images, highlighted buttons and text. The tutorial is optional and the user can choose to skip it at any point by selecting the according option on the menu or by moving towards the door.

7. Public 3D viewer

The main mechanism that is used for the dissemination of the CHOs and their related data is the 3D viewer, which incorporates some innovative features in terms of object information delivery to

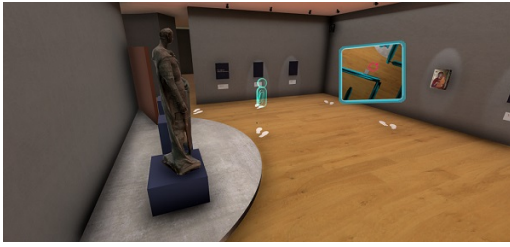


Figure 4: The teleportation to fixed point movement method. An Indicator appears showing the user's desired orientation. The minimap is also in the user's view to assist navigation.



Figure 5: (a) The user can skip the tutorial at any time, (b) The tutorial scene with the sample exhibit.

the users. In a simple scenario, the user runs the application of VM and enters the main menu. Firstly, the user reads the hints on how to navigate in the VM. Then, the user selects to visit one of the available rooms. Inside the room, the visitor clicks on the steps to transit and uses the mouse to look around the exhibition. After finding a point of interest, meaning an exhibit, clicks on it to view its details. In the 3D viewer, the visitor reads the title and description of the item, while can observe the object closer by dragging or rotating it. By using the scroll wheel, the user can zoom in to the object. The user can view the available measurement points, each one of them may have multiple measurements, derived from different sensors (Figure 6). The current public 3D viewer also allows the user to view an object in different time periods. This functionality has been implemented in the Conservation room, where material samples are exhibited. These samples were artificially aged in different time instances and their texture is being used to represent the virtual objects. The samples are exhibited in time period t_0 . By clicking on a sample, the user can inspect it in the 3D viewer. The visitor can view the same object in different age state (t_0 , t_1 , t_2 , t_3) by pressing the corresponding button in the information panel (Figure 7). The 3D viewer in VR retains all its capabilities as the desktop/web application version, while some alternations regarding the GUI have been implemented in order to align with the VR system interaction requirements.

8. Conclusions and future work

The proposed VM offers the possibility to the users to practice a part of the curatorial process of the VM through the management tool: the curator can insert CHOs to the exhibition rooms, along with the available metadata and measurements. From the other hand, the visitor of the VM, that can be either a curator/conservator or a non-field expert user, have access to the CHOs in a way that would not be possible in a physical museum. Additional, scientific data are available for interested audience and conservators. The measurement graphs and images are valuable information for the

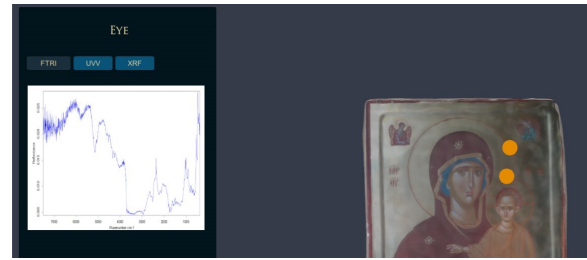


Figure 6: The visitor observes the measurements derived from sensors, correspond to the selected measurement point

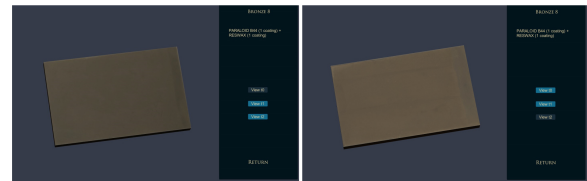


Figure 7: The reference panel "Bronze 8" in time instance t_0 and t_2

conservators and are being delivered through an immersive and attractive experience in the virtual world. Additional data about the CHO's state in different time periods, can be derived by observing both, the 3D CHOs and the reference material panels. The visitors can transit through the museum rooms forming their own sequence without excluding the linear option. The structure of the different room entities can support the expandability of the VM. The VM is accessible through web, desktop, while the Oculus rift edition offer a fully immersive experience that could enhance the interest of the audience for cultural heritage content and motivate them for further exploration. The management tool can gradually be expanded to support further the curatorial process. The user could be able to combine, edit and delete rooms of a VM, as well as select and customize generic museum room types, and exhibit typologies such as hanging or standing exhibits along with their customizable lighting. In terms of the presentation of the CHOs, additional type of data could be available for exploration, such as multimedia content. Storytelling elements could be used, while it is evident that storytelling techniques can enforce the emotional impact and enhance learning outcomes in applications with educational purposes [VII7]. Existing storytelling guidelines for the virtual museum context [Pal17] could be used. The evaluation of the management tool and the VM in terms of usability and perceived user experience, would give us an insight for further improvements and expansions.

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