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Short Paper

Digital 3D Documentation Curation Platform for Cultural Heritage Sites

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Figure 1: *Cultural Heritage Site & Digital Museum*

Abstract

Using an abandoned stronghold under renovation as a cultural heritage use case, this paper focuses on methods for the creation of a digital documentation platform that aims at the preservation of both the physical site, through the recreation of a 3D environment, and the intangible historical and sociocultural elements through an interactive game like experience. The result is a solution that allows the user to explore a 3D environment while observing the recreated structures of the stronghold based on 3D models, and the development of interactive methods to promote the visualization of historical content placed in such environment. The solution also allows the evolution of the system, making it possible to rearrange and curate the environment into different setups. The system went through an evaluation process where users tested the diverse features and the results express a positive response from the users towards the usability of the platform, as well as a positive opinion on the virtualization of the historical site and the interactive methods for content visualization.

CCS Concepts

• ***Computing methodologies*** → *Computer Graphics;* • ***Applied computing*** → *Cultural Heritage;*

1. Introduction

The development of technologies for the creation of virtual environments (VE) and/or virtual worlds (VW) introduces new possibilities for the work in the preservation and documentation of cultural heritage. These technologies introduce the ability to partially or completely recreate an entire environment that allows the immersion in the cultural values that are being represented. As an example, the recreation of a city and its artifacts allow for its preservation even if they deteriorate in the future. Enhanced immersion and engagement are achieved when these environments are experienced through an interactive system using the same building blocks and logic of 3D games aiming for a simulation of the real world that is relevant for the user. This work presents a generalized solution for the representation of cultural heritage through the usage of 3D tools and virtual environments. This is important because the majority of these projects [Zar04; RDH15; RRvS*21] aim at a specific museum or historical site, and do not provide the ability to adapt the application nor have any reconfiguration process implemented.

This work aims to provide solutions for: **(1)** the challenges of replicating a real heritage site in an explorable virtual world, **(2)** how to curate a virtual exhibition that tells the story of the site, and, **(3)** how to visualize the artifacts and documents that are related with said heritage site. As an answer to these challenges, we present a framework to design and implement immersive and interactive applications based of historical heritage sites through virtual environment recreation and game components. We also consider the integration of media storage providing initial implementations of interactive media visualisers for the stored content within the application, enabling further interactions from the user with the heritage content.

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2. Related Work

The goal of preserving cultural heritage using graphics and interactive techniques [CMN*10] means is very important and has been extensibly studied.Cultural heritage can be seen as the indicators and values that characterize a society or a community and its presence. According to Vecco [Vec10], cultural heritage can be partitioned into two different categories, tangible and intangible culture. Mah et al. [MYT*19] highlights that have been few the works towards the creation of interfaces that were able to assimilate both tangible and intangible aspects of cultural heritage. One of these initiatives, Google Arts and Culture an online platform where exhibits of museums worldwide are made accessible to the public, has the tangible and intangible aspects on their website kept disparate in terms of virtual tours and interactive storyboards.

Several techniques and systems are used to create cultural heritage experiences, and one of the most common now are the interactive digital storytelling (IDS) systems [Ale17] which is recommended by Athena Plus to the institutions that pretend to transmit cultural heritage information. Although being the recommended approach it faces several challenges exposed in Schoenau-Fog [Sch15], being the main issue, the so called narrative paradox [Ayl00], defined as the clash between the freedom that can be given to the user and which actions are allowed, and what constraints can be enforced on the user to preserve the main course of the story [Sch15]. Reoccurring problems related to the narrative paradox are for example when a portion of the story is connected to an object or a part of the environment that can only be accessed by a trigger activated by the user [SRH*20]. Users might miss finding these triggers and not perceiving important information as a result. There are several variations in how the stories are told such as 360º videos [LA03], Web-based VR [SRH*20] or through RPG games [Ayl00].

Bekele et al. [BPF*18] concluded that the usage of virtual environment applications in CH has been primarily for virtual museums and then for education, reconstruction, and exploration purposes.For cultural heritage but also for cultural propagation Bartley et al. [BH08] discuss about the advantages of reconstructing cultural sites in the form of virtual tourism. VR has technological and immersive aspects that allow several definitions since it's a complex technology complex technology that creates a digital environment with which users may interact and which they feel completely immersed within [Bho09]. Other projects that use 3D or VR include: Virtual Heart of Central Europe (VHCE)[Zar04], Vrouw Maria [RDH15] and MayaArch3D [RRvS*21].

Selmanović et al. [SRH*20] studies the concept of interaction and get to the conclusion that it is one of the key points connected to immersion, being the main feature of a system that wants to create a sensation of presence to the user. They partition the modes of interaction into five different modes: Navigation, Selection, Scaling, Manipulation and Menu Interaction. Selection has two key elements, identification and actual selection, Mendes et al. [MMS*17] proposed a selection taxonomy that includes cardinality - the number of objects that can be selected simultaneously and gradual refinement-gradual sub selection among multiple larger groups of initially selected objects. Dachselt et al. [DH07] makes an intensive study on several 3D menu options and builds a comparison between the possible options and discusses a taxonomy for them.

3. Cultural Heritage Site

The old building structure was used as the case study for this project, built in *Presídio da Trafaria* used as a complex to provide for storage of materials and a place for merchants, and later used as prison in the XX century. It is located in Trafaria, Portugal. The project intends to preserve a digital reconstruction of the stronghold with the VE and provide a system that can include other cultural heritage elements of such as images, music, objects through various modes of interaction.

In order to achieve a platform for the exploration of a historical site, and, the creation of visualization mechanisms for the introduction of media content, two steps were required. Firstly a data collection phase to gather the necessary media and models and later a 3D Virtualization phase in which the gathered data was transitioned to a 3D environment using the curation system. In Figure 2 we present and propose a framework to allow a more structured method for building applications for CH that rely on a 3D environment, allow management of an archive and implement media visualization. In summary, a first step of data collection needs to occur to gather the necessary resources to build the environment, following there is a middle step with the implementation of the virtual environment through a game engine, and finally the implementation of the various features that will provide the user with the designed interactions.

4. Features of the 3D Documentation Platform

The platform uses a 3D representation of the site, supports FPS-style navigation, allows the creation of a virtual exhibition and presents the different media in dedicated media players and supports an editor mode. The goal is to present and virtually preserve the memory of the historical site. All the documents are organized in hierarchical folders allowing for the direct manipulation of media files outside the main application. In this section we explain the main features of our Curator Platform.

One of the key aspects of this project is the importance of the historical value and the recreation of the real world in a VE. Because

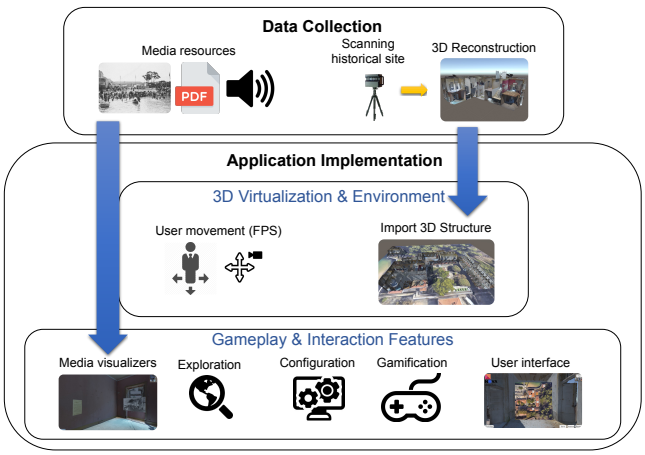

Figure 2: *3D environment application framework*

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Figure 3: *Guide system **A**: Text left by guide at checkpoint **B**: Object (light) representing guide in the next checkpoint*

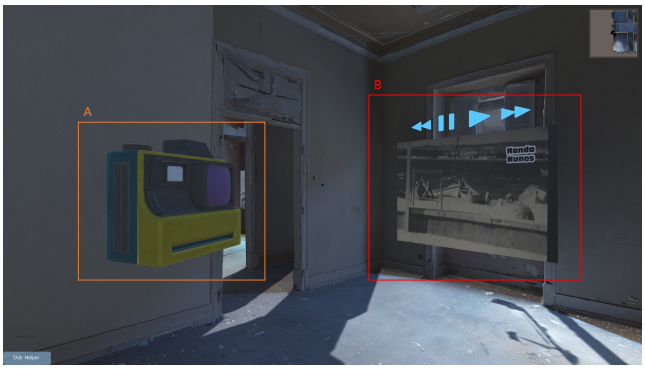

Figure 4: *Video media Players A: 3D Objects that represents 2D interaction video player B: 3D Interaction video player*

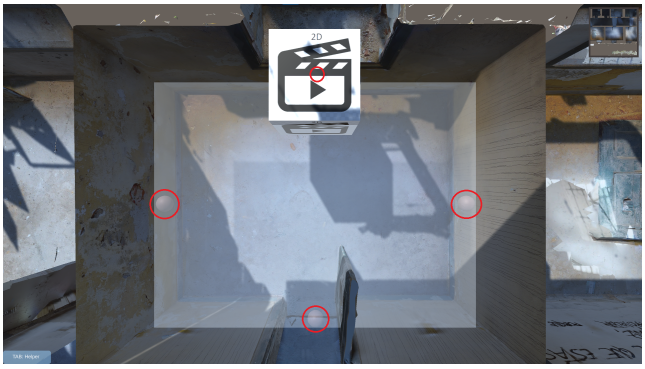

Figure 5: *Aerial view of the Media Room and media player in editor mode. Snapshot points in red*

of this, it makes sense to develop systems that allow the user to be able to explore and experience this space. Therefore we developed three different exploration methods:

Free Exploration – The user can explore the environment at free will using a First-Person Shooter (FPS) game approach.

Assisted Exploration – In contrast to the free exploration, the assisted exploration offers an exploration where the system takes partial or full control of the movement. Assisted exploration (and Auto exploration) were developed to achieve this exploration type. The Assisted Exploration recreates what already exists in reality, the guided tours on museums, in which the user will be guided and led to a set of specific locations and given certain instructions that are part of the previously created tour (Figure 3).

Automatic Exploration - implements a systems that totally takes control of the movement component from the user.

In addition to the different types of exploration there is also a map menu that allows to quickly change the building where we are. Alongside the virtualization of the cultural heritage site, allowing its exploration, the goal of the project is also to provide a platform and tools to virtualize media content and make it accessible to the user through different interaction approaches.

This virtualization of content and the idea of bringing this content to the user led to decisions about what content should be made available. The final version of the system supports the following media types: image, video, audio, 3D objects, text documents (pdf, word, odf) and raw text. As the design of the media players progressed, the possibility to go even further when developing different modes to interact with the digital content became more present, resulting in the creation of 2D and 3D media-players interaction concept (Figure 4). To enable the configuration of the application, within the virtual environment itself, an editor mode was developed (Figure 5).

5. Preliminary Results

In order to understand whether our solution was able to achieve the objectives, a preliminary study was conducted evaluating the platform as a whole but also the implemented features.

The testing session with an expected time of 35 min was completed by 25 participants with a completion time between 30 min and 40 min. The population that completed the session was composed of 25 participants, spread over 15 male and 10 female, with an age range from 19 to 50 with a median of 25. The education level within the participants varies with 60% having completed some level of higher education. Most of the participants played games and/or play it somewhat frequently fulfilling a percentage of 72% although only 48% of the total group had previous experience with first-person shooter games. As the project can have similarities with digital or virtual museums this demographic parameter was also questioned revealing only 32% of the total participants had a previous experience with virtual museums. The session consisted in the completion of several tasks inside the project application, with the answer questions after each task. After the completion of the tasks the participants were also asked to fill a population characterization form and a System Usability Survey (SUS) form to evaluate the application system, which resulted with a SUS normalized score of 75 points, which reveals a positive conclusion on the usability.

The tasks in the testing session were directed towards evaluating the implementation of the virtual environment and the implementation of the various features. The first result concerns a task where the user was asked to make use of the movement controls to explore the virtual environment to complete the task by finding a specific

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Table 1: *Games experience influence on free exploration*

Experience with games	#	Completion Time	T-Test (CI = 95%)
Some	16	28.75 ± 7.44	t(25) = -6.669
None	9	48.78 ± 5.86	p<0.00001
Total	25	36.96 ± 11.84	

Table 2: *Preference in media player interaction*

Preferred Player	Image	Video	Audio
2D	24%	24%	40%
3D	76%	76%	60%

place in the virtual world. With the results of the task completion time the demographics statistic relating to whether or not the user had previous experience with games it was concluded that considering a confidence interval of 95% there is evidence that previous experience in games has significant impact on the performance on completion the exploration task, indicating that indeed users with previous experience are prone to adapt quicker to the controls, Table 1 shows a summary of this result.

Another interesting result was the result regarding a task where the users were instructed to interact with 6 media players three with 2D interaction and three with 3D interaction. Since each was interacting with the same media players, in order to not have the same results and achieve a feasible study, the users were divided into 4 groups with a different order of usage of the media players, using a Latin-square assignment. The results observed aimed at gathering information on the possibility of a preference from the users towards the usage of media players with 2D or 3D interactions, the outcome indicated a significant preference of the 3D interaction media players, Table 2 summarizes these results. This outcome could also be related to an issue seen during the testing session as more than half the users were not able to understand initially how the 2D interaction media players worked.

6. Conclusions

Using virtual environments to help create platforms to bring the real world and its cultural heritage to users, is a prime subject to explore, as one of the major concerns has been the documentation of the cultural heritage. In this context, using an old building structure as a case study scenario, this paper focused on exploring the creation of a virtual environment withholding cultural heritage content and introducing interactive elements to provide an entertaining experience as well as permitting a change of the environment, so that the platform can be updated throughout time.

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References

[Ale17] ALEXANDER, BRYAN. *The New Digital Storytelling: Creating Narratives with New Media–Revised and Updated Edition*. Abc-clio, 2017 2.

[Ayl00] AYLETT, RUTH. "Emergent Narrative, Social Immersion and "Storification"". *1st International Workshop on Narrative and Interactive Learning Environments (NILE 2000)* (2000), 35–45 2.

[BH08] BARTLEY, ELIZABETH A. and HANCOCK, JOHN E. "Virtual reconstructions as destination tourism?": *International Journal of Digital Culture and Electronic Tourism* 1.2/3 (2008), 225. ISSN: 1753-5212. DOI: 10.1504/ijdcet.2008.021409 2.

[Bho09] BHOURI, IMEN. "On the projections of generalized upper Lq-spectrum". *Chaos, Solitons and Fractals* 42.3 (2009), 1451–1462. ISSN: 09600779. DOI: 10.1016/j.chaos.2009.03.056 2.

[BPF*18] BEKELE, MAFKERESEB KASSAHUN, PIERDICCA, ROBERTO, FRONTONI, EMANUELE, et al. "A survey of augmented, virtual, and mixed reality for cultural heritage". *Journal on Computing and Cultural Heritage* 11.2 (2018). ISSN: 15564711. DOI: 10.1145/3145534 2.

[CMN*10] CORREIA, NUNO, MOTA, TARQUINIO, NÓBREGA, RUI, et al. "A Multi-Touch Tabletop for Robust Multimedia Interaction in Museums". *ACM International Conference on Interactive Tabletops and Surfaces*. ITS '10. Saarbrücken, Germany: Association for Computing Machinery, 2010, 117–120. ISBN: 9781450303996. DOI: 10.1145/1936652.1936674 2.

[DH07] DACHSELT, RAIMUND and HÜBNER, ANETT. "Three-dimensional menus: A survey and taxonomy". *Computers and Graphics (Pergamon)* 31.1 (2007), 53–65. ISSN: 00978493. DOI: 10.1016/j.cag.2006.09.006 2.

[LA03] LOUCHART, SANDY and AYLETT, RUTH. "Solving the narrative paradox in VEs - Lessons from RPGs". *Lecture Notes in Artificial Intelligence (Subseries of Lecture Notes in Computer Science)* 2792 (2003), 244–248. ISSN: 03029743. DOI: 10.1007/978-3-540-39396-2_41 2.

[MMS*17] MENDES, DANIEL, MEDEIROS, DANIEL, SOUSA, MAURÍCIO, et al. "Design and evaluation of a novel out-of-reach selection technique for VR using iterative refinement". *Computers and Graphics (Pergamon)* 67 (2017), 95–102. ISSN: 00978493. DOI: 10.1016/j.cag.2017.06.003 2.

[MYT*19] MAH, OSTEN BANG PING, YAN, YINGWEI, TAN, JONATHAN SONG YI, et al. "Generating a virtual tour for the preservation of the (in)tangible cultural heritage of Tampines Chinese Temple in Singapore". *Journal of Cultural Heritage* 39 (2019), 202–211. ISSN: 12962074. DOI: 10.1016/j.culher.2019.04.004 2.

[RDH15] REUNANEN, MARKKU, DÍAZ, LILY, and HORTTANA, TOMMI. "A holistic user-centered approach to immersive digital cultural heritage installations: Case Vrouw Maria". *Journal on Computing and Cultural Heritage* 7.4 (2015), 1–16. ISSN: 15564711. DOI: 10.1145/2637485 1, 2.

[RRvS*21] RICHARDS-RISSETTO, HEATHER, ROBERTSSON, JIM, von SCHWERIN, JENNIFER, et al. "Geospatial Virtual Heritage: A Gesture-Based 3D GIS to Engage the Public with Ancient Maya Archaeology". *Archaeology in the Digital Era* February 2021 (2021), 118–130. DOI: 10.1017/9789048519590.013 1, 2.

[Sch15] SCHOENAU-FOG, HENRIK. "Adaptive storyworlds". *International Conference on Interactive Digital Storytelling*. Springer. 2015, 58–65 2.

[SRH*20] SELMANOVIĆ, ELMEDIN, RIZVIC, SELMA, HARVEY, CARLO, et al. "Improving Accessibility to Intangible Cultural Heritage Preservation Using Virtual Reality". *Journal on Computing and Cultural Heritage* 13.2 (2020). ISSN: 15564711. DOI: 10.1145/3377143 2.

[Vec10] VECCO, MARILENA. "A definition of cultural heritage: From the tangible to the intangible". *Journal of Cultural Heritage* 11.3 (2010), 321–324. ISSN: 12962074. DOI: 10.1016/j.culher.2010.01.006 2.

[Zar04] ZARA, JIRI. "Virtual reality and cultural heritage on the web". *7th International Conference on Computer Graphics and Artifiical Intelligence* May (2004), 101–112. URL: http://dcgi.felk.cvut.cz/home/zara/papers/Zara-3IA04.pdf 1, 2.

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