

Developing an eXtended Reality platform for Immersive and Interactive Experiences for Cultural Heritage: Serralves Museum and Coa Archeologic Park

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ABSTRACT

Digital Heritage and Digital Humanities focus on distinct typologies of heritage: tangible and intangible Cultural Heritage (CH) objects and their preservation, education, and research versus the application of digital technologies to support research in the humanities. Both allow scholars to go beyond textual sources to integrate digital tools into the humanistic study. This project aims at supporting a new way of experiencing CH in the Serralves Museum and Coa Archeologic Park through more involving and culturally-qualified user experience. The main goal is to understand the potential of eXtended Reality within CH while also proposing the idea of developing a digital experience platform: an authoring tool based on an engine with core experiences functions that can be applied for developing multiple experiences for CH. This platform will contribute to new approaches, technologies, and tools for creating, processing, and delivering immersive and interactive content for engaging and meaningful experiences in these specific CH environments.

Keywords: Cultural Heritage, Serralves Museum, Coa Archeological Park; Immersive and Interactive Experience, eXtended Reality, Platform

Index Terms: •Human-centered computing~Human computer interaction (HCI)•Human-centered computing~Human computer interaction (HCI)~Interaction paradigms~Virtual reality•Human-centered computing~Human computer interaction (HCI)~Interaction paradigms~Mixed / augmented reality

1 INTRODUCTION AND OBJECTIVES

The aim of this research proposal is to understand the potential of extended reality within CH in the Serralves Museum and Coa Archeologic Park while also proposing the idea of developing a DXP to assist the design and development of immersive and interactive experiences for CH.

To achieve this goal, the following objectives have been identified:

Task 1 - Conduct a literature review to identify best practices in Portugal and in Europe only in contemporary art museums and archaeological -parks and sites. Examine critically the theory of experience design, interactive design, and CH as a theoretical underpinning to understand how these experiences can contribute to CH environments. Identify which elements of XR can contribute to creating engaging and meaningful experiences in CH environments. Identify individual public experience with these experiences in CH environments.

Task 2 - Design DXP architecture and implement an open platform. By identifying contextual parameters occurring during the experiences with the XR in the CH environment. After this, we will develop a conceptual framework elaborating key experiences elements, contextual parameters, and individual public experience for XR experiences to elicit engaging and meaningful experiences with the CH environment by combining interdisciplinary research of social sciences.

Task 3 - After the development, it will be needed to test and validate the platform, by creating XR experiences using the created DXP and validate these with expositions and questionnaires to the public. This will allow for studying user's future behavioral patterns in such environments. These experiences will be created for two locations: the Serralves Museum and Coa Archeologic site.

Task 4 - Contribute to knowledge dissemination by attending and presenting scientific papers in international conferences in the field and published in journals. It is expected to be published at least one scientific article per year during the research..

2 STATE OF THE ART

Cultural environments, specifically museums and archaeological sites, in the last years, have been promoting - new, more engaging immersive and multi-sensorial approaches, to permit a direct way to the information via playful and exciting dimension, prevail over the traditional hierarchy on exposition space, contents and visitors.

A multimedia approach to the diffusion, communication, and exploitation of CH is a well-established trend worldwide, that will grow in a post COVID19 scenario. Several studies demonstrate how the use of new and combined media enhances how culture is experienced [1]. These benefits the number of people (including disabled persons) who can have access to knowledge, the quality of the diffusion and the experience of the knowledge itself. Accordingly, eXtended Reality (XR) [2] is the most used in the CH field.

The XR enabling technologies to range from audio-visual display technologies, tracking and registration systems, interaction methods, and virtual environment modeling techniques [1, 3, 4]. XR technologies and interaction methods are being used for educational, explorative, and exhibition enhancement purposes [5, 6].

Improving cultural knowledge in XR CH applications requires that the immersive reality technology and interaction method allows a contextual connection, collaboration, and engagement between users and the virtual environment [7, 8].

In The Museum of Pure Form [9], a system for visitors allows them to interact with digital models of some sculptures through touching sense; The Leventis Museum uses an application that

gives the user the chance to see the virtual replicas of archaeological artifacts superimposed on a surface, while they can use their hands to interact with them in real time [10].

In the Archaeological Park of the Colosseum, Rome, these technologies allows visitors to experience the “Domus Aurea VR” application like a video-story presenting a reconstruction of Nero’s palace. The visitors can experience reconstructed rooms of the Domus, with the virtually “restored” light inside the monument [11]; in the “Museo Virtuale della Via Flaminia Antica” a VR system is used to allow visitors to move through the Livia’s Villa, in its current archaeological conditions and the original ones [12].

Serralves Museum in Portugal leads a multidisciplinary approach in contemporary art. The Educational Service develops projects targeted to help publics to gain awareness about contemporary art encouraging contact with a manifold of aesthetic expressions. The Museum actively promotes the decentralization of contemporary art and culture with exhibitions of works from the Collection and other activities staged outside Porto city, as well as activities for schools including guided tours, workshops, and workshop-visits. [13]

The archaeological CôaPark, World Heritage Site since 2010, is an extension of the Côa Valley [14] with more than a thousand outcrops with rock art, identified in over 80 different sites, predominantly from the Upper Paleolithic, some 25,000 years ago. The Côa Museum allows a small contact with the vast rock art collection and interpretation complexities in the Valley. In 2019, AR and VR were introduced in the Museum but no solution is still available for the main collection as it lies outside the physical walls of the Museum.

3 DETAILED DESCRIPTION OF THE PROJECT

The project will start by performing a literature review in order to identify and compare the existing immersive reality technologies and platforms and interaction methods used in the CH domain focusing on the museums and archeological sites areas. First, the study will gather information of enabling XR technologies (video and sound capture, tracking and registration, audio-visual display technology, interaction methods, and virtual modeling environment methods) and standards, and existing projects and applications in these CH domains. XR combines core features of AR, VR, and MR and everything between these interconnected fields. It unites real and virtual environments and relates technologically powered interactions between humans and machines. As XR depends on each of the underlying technologies, innovations that bring about changes also create new XR experiences [15].

Projects and experiences within the areas of CH museums and archeological parks and sites, will be analyzed regarding the technology’s or the interaction approach’s capability and/or established skill to: (a) enable a contextual connection between users, digital content, and cultural context, (b) facilitate collaboration among users, and (c) allow engagement with the cultural context in the digital environments and the digital environment itself. This process will allow identifying key collaborative and multimodal XR technologies and interaction methods that can be used in a CH application and the different kinds of users and their needs, according to the analyzed experiences. This analysis process will also be applied to the experiences that we will develop.

The platform will be able to enhance, provide, and augment the experience done by the visitors using a system based on new multi-layered and narrative modalities. The full open platform will include three subsystems: a web portal, an application module to support Virtual Reality, and application modules to support Augmented Reality.

The design research approach will follow an integrative approach that explores user experiences in order to inform or renew the

experience design. Integrative research aims for iterations by testing and feeding back the testing outcome from experience evaluations.

In a general approach, it is intended to adopt design-based research (DBR) focusing on the user. This methodology conducts a single setting over time with iterative cycles of design, leading to outcomes from a mix of qualitative and quantitative approaches. There is a collaboration between practitioners and researchers, generating knowledge that can be used in practice.

According to the International Organization for Standardization [16], the user-centered design consists of four phases. The first one concerns identifying the users, goals, tasks, and the environment. Second, the design specifications are yielded from the previous phase. The third phase embraces the development of a prototype to test design solutions. Last, in the fourth phase, an evaluation is done and assessed. If needed, the procedure is repeated as an iterative cycle of design until the design solution satisfies the requirements of use [17].

During the first phase, it is intended to identify the users, goals, and tasks adopting qualitative research with the use of an interview. At this stage, the research will focus on convenience sampling.

Second, a wireframe with the design specifications collected from the interview will be generated to identify the technical challenges and we intend to apply the persona strategy.

In the next phase, the objective is to develop a set of prototype experiences to test the interactions and hypothesis. We expect to explore VR equipment and interaction devices to allow natural gestures and 3D interactions.

Last, it will be conducted a quantitative method (an electronic form), as a usability test with the users in order to evaluate and answer the main research questions. We intend to give users some tasks and obtain quantitative metrics like completion rates between experiences, and interaction accuracy.

With the results in hand, an assessment will be made to develop a DPX and to test it again. These processes allow identifying key functional and technical requirements to define the platform architecture. The architecture will follow an interconnected layers structure: a presentation layer (users, admin, content producers, art director), a logic layer (storytelling module and decision-making algorithm), a data layer (3D models, images, video, sound, etc) and a hardware layer (to provide support to input and output systems such as HMD, monitor, tracker, depth camera, etc).

After the development of DPX, we will create four XR experiences. The experiences will be carried out in previously defined places. One of the locations will be the Serralves Museum, where two XR experiences will be exhibit. For art museums, XR technology presents as a powerful tool that can add interpretive content to the displayed or store artwork, connect with existing documentation according to visitor preferences and their interests, allowing a rich and engaging museum visit experience [18, 19]. Serralves has a long tradition of offering experiences that integrate art and audience engagement through its three education services (art, park, and Manuel de Oliveira Cinema House). The second location will be in Coa Archeologic Parc, where we will be using paleolithic rock engravings to create two more XR experiences. For Archeologic Parcs, XR technology brings new tools that can provide historically accurate reconstructions of archeological sites and relevant contextual information to allow for a richer and more impactful visitor experience [20, 21].

A user experience assessment procedure should be defined. Evaluation typically follows a multi-method approach. First, a previous analysis is performed on the general CH environment. This will allow us to analyze the context of interaction and the exhibition accessibilities, how the visitors typically come near the space and the objects are displayed. Then, an user experience survey on public, during the CH visit at the XR experience, by

means of observations, to validate and study the viability of the proposal experiences. Last, questionnaires, to confirm the users' feedback in order to provide the level of understanding of the users when interacting with the experience, the usability, and the interface design. Participation in the survey will be on a voluntary basis and anonymous.

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REFERENCES

- [1] Bekele, M. K., Town, C., Pierdicca, R., Frontoni, E., & Malinverni, E. V. A. S. (2018). A Survey of Augmented , Virtual , and Mixed Reality. *ACM Journal on Computing and Cultural Heritage*, 11(2), 36. <https://doi.org/10.1145/3145534>
- [2] Fast-Berglund, Å., Gong, L., & Li, D. (2018). Testing and validating Extended Reality (xR) technologies in manufacturing. *Procedia Manufacturing*, 25, 31–38. <https://doi.org/10.1016/j.promfg.2018.06.054>
- [3] Billingham, M., Clark, A., and Lee, G. (2015). A survey of augmented reality. *Foundations and Trends R in Human-Computer Interact.* 8, 73–272. doi: 10.1561/11000000049
- [4] Kim, K., Billingham, M., Bruder, G., Duh, H. B.-L., and Welch, G. F. (2018). "Revisiting trends in augmented reality research: a review of the 2nd decade of ISMAR (2008–2017)," in *IEEE Transactions on Visualization and Computer Graphics*. doi: 10.1109/TVCG.2018.2868591~
- [5] Scott, M. J., Parker, A., Powley, E., Saunders, R., Lee, J., Herring, P., et al. (2018). Towards an Interaction Blueprint for Mixed Reality Experiences in GLAM Spaces: The Augmented Telegrapher at Porthcurno Museum. Burlington, MA; Berlin; Budapest: ScienceOpen, Inc. doi: 10.14236/ewic/HCI2018.135
- [6] Zhao, C., Twidale, M. B., and Nichols, D. M. (2018). "Acquiring metadata to support biographies of museum artefacts," in Paper Presented at the International Conference on Asian Digital Libraries (Hamilton). doi: 10.1007/978-3-030-04257-8_31
- [7] Caputo, F. M., Ciortan, I. M., Corsi, D., De Stefani, M., and Giachetti, A. (2016). "Gestural interaction and navigation techniques for virtual museum experiences," Paper Presented at the AVI* CH (Bari)
- [8] Rahim, N., Wook, T. S. M. T., and Zin, N. A. M. (2017). analysis on user interaction in virtual heritage: virtual museum environment. *Indian J. Sci. Technol.* 10, 1–10. doi: 10.17485/ijst/2017/v10i48/120775
- [9] Loscos, C., Tecchia, F., Frisoli, A., Carrozzino, M., Widenfeld, H., Swapp, D., & Bergamasco, M. (2004). The Museum of Pure Form: touching real statues in an immersive virtual museum. *VAST*, 271–279. <https://doi.org/10.2312/VAST/VAST04/271-279>
- [10] Kyriakou, P., & Hermon, S. (2019). Can I touch this? Using Natural Interaction in a Museum Augmented Reality System. *Digital Applications in Archaeology and Cultural Heritage*, 12, 9. <https://doi.org/10.1016/J.DAACH.2018.E00088>
- [11] Parco Archeologico del Colosseo. (2017). THE DOMUS AUREA. <https://parcocolosseo.it/en/area/the-domus-aurea/>
- [12] Forte M., 2007. La villa di Livia: un percorso di ricerca di archeologia virtuale. L'ERMA di BRETSCHNEIDER, 2007.
- [13] Museu Serralves. (2020). Apresentação. <https://www.serralves.pt/pt/fundacao/o-museu/apresentacao/>
- [14] UNESCO, (2010). Cão e Siega Verde. <https://www.unescoportugal.mne.pt/pt/temas/proteger-o-nosso-patrimonio-e-promover-a-criatividade/patrimonio-mundial-em-portugal/coa-e-siega-verde>
- [15] Schreer, O. (2019) Current State of XR Technologies & Applications, and Ethical Aspects, EU XR Forum, 12 December 2019, Brussels
- [16] ISO/IEC 18039:2019. (2019). Information technology — Computer graphics, image processing and environmental data representation — Mixed and augmented reality (MAR) reference model. <https://www.iso.org/standard/30824.html>[16] de Clerk, M., Dangelmaier, M., Schmierer, G., & Spath, D. (2019). User Centered Design of Interaction Techniques for VR-Based Automotive Design Reviews. *Frontiers in Robotics and AI*, 6, 13. <https://doi.org/10.3389/frobt.2019.00013>
- [17] de Clerk, M., Dangelmaier, M., Schmierer, G., & Spath, D. (2019). User Centered Design of Interaction Techniques for VR-Based Automotive Design Reviews. *Frontiers in Robotics and AI*, 6, 13. <https://doi.org/10.3389/frobt.2019.00013>
- [18] Kaghat, F. Z., Azough, A., Fakhour, M., & Meknassi, M. (2020). A new audio augmented reality interaction and adaptation model for museum visits. *Computers & Electrical Engineering*, 84, 106606. <https://doi.org/10.1016/J.COMPELECENG.2020.106606>
- [19] Bekele, M. K. (2019). Walkable Mixed Reality Map as interaction interface for Virtual Heritage. *Digital Applications in Archaeology and Cultural Heritage*, 15, 11. <https://doi.org/10.1016/J.DAACH.2019.E00127>
- [20] Younes, G., Kahil, R., Jallad, M., Asmar, D., Elhajj, I., Turkiyyah, G., & Al-Harithy, H. (2017). Virtual and augmented reality for rich interaction with cultural heritage sites: A case study from the Roman Theater at Byblos. *Digital Applications in Archaeology and Cultural Heritage*, 5, 1–9. <https://doi.org/10.1016/J.DAACH.2017.03.002>
- [21] Unal, M., Bostanci, E., & Sertalp, E. (2020). Distant augmented reality: Bringing a new dimension to user experience using drones. *Digital Applications in Archaeology and Cultural Heritage*, 17, e00140. <https://doi.org/10.1016/J.DAACH.2020.E00140>