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Exploring Methodologies to Create a Unified VR User-Experience in the Field of Virtual Museum Experiences

Rojin Bayat*, Elios De Maio*, Jacopo Fiorenza†, Massimo Migliorini* and Fabrizio Lamberti†
*Extended Reality Lab, Fondazione LINKS, Turin, Italy
Email: rojin.bayat, elios.demaio, massimo.migliorini@linksfoundation.com
†Dipartimento di Automatica e Informatica and VR@POLITO, Politecnico di Torino, Turin, Italy
Email: jacopo.fiorenza, fabrizio.lamberti@polito.it

***Abstract*—The emergence of Virtual Reality (VR) and metaverse have opened doors to new research opportunities and frontiers in User Experience (UX). Within the cultural heritage domain, one of the key concepts is that of the Virtual Museums (VMs), whose definition has been extended through time by many research works and applications. However, most of the studies performed so far focused on only one application, and studied its UX without taking into account the experience with other VR experiences possibly available in the VM. The purpose of this work is to give a contribution for an optimal design to create a unified UX across multiple VR experiences. More specifically, the research included the development of two applications, respectively a VM in a metaverse platform and a virtual learning workshop as an individual application. With this premise, the study will also consider two fundamental elements for an effective UX design: a Virtual Environment (VE) and an Intelligent Virtual Avatar (IVA). In particular, the latest was developed following current trends about generative AI, integrating an IVA powered by a Large Language Model (LLM).**

***Index Terms*—Virtual Reality, Metaverse, Meta-museums, User-Experience Design**

I. Introduction

In general, User Experience (UX) defines the people's feelings, perceptions and responses that result from the use and/or imagined use of a product, system or service [1].

In recent years, the rapid advancement of VR has led to a new era of exploration and innovation within the topic of UX. One of the fields that has been widely explored is the cultural heritage one, which includes several experiences adapted from traditional museum's UX: virtual visits, Virtual Exhibitions (VEX) and Virtual Workshops (VWs) are the most common, generally located in a VM environment. One of the first definitions for this aspect was given in the early 2000s in the work proposed by Mase et al. [2], where the term of "Meta-Museum" was coined. In this case, it was defined as a space that "*blends virtual reality and artificial intelligence technologies with conventional museums to maximize the utilization of the museum's knowledge base and to provide an interactive, exciting and educational experience for visitors*". Some of the key features of the approach proposed included the presence of personal artificial guidance agents for the visitor and *"visitor oriented and personalized access, experience, and learning of exhibitions"*. The definition was eventually extended over time, with several studies that focused on building valuable experiences in VMs or related cultural heritage environments, evaluating learning and UX aspects [3] [4] [5]. With the advent of the metaverse era, this type of experiences became even more complex, introducing shareable virtual environments and virtual social dynamics into the process. Moreover, the appearance of chatbots powered by LLMs (e.g. ChatGPT) represented a further paradigm shift when it comes to create IVAs, since this type of models, unlike the traditional approaches, provide automatically generated responses based on the training data. Regarding the UX aspect, current approaches tend to evaluate VR experiences in isolation, although a Virtual Museum Experience (VME) could possibly comprise multiples sub-activities (e.g. visits, workshops) requiring different levels of interaction. The purpose of the proposed research is to explore the domain of UX in the field of VMs across multiple VR experiences. This objective was conceptualized through the creation of two distinct VMEs: "Piazza Memorabilia" within a metaverse platform, and a Renaissance-era learning laboratory set within a VW. Derived from the guidelines found in the state of the art, two elements in particular were considered in this preliminary investigation in order to build a unified UX in the VM domain: VE and IVA. The former was designed in order to promote user's engagement and curiosity around the explorable environment, without neglecting the coherence between the two VEs developed. The latter was designed by integrating a LLM into the system (GPT-4), in order to build an effective conversational IVA.

II. Related Works

A. UX in traditional museums

Several studies have widely explored the specific topic of museum experiences. The most notable in this field are Falk and Dierking's Museum Experience [6] and Packer and Ballantyne's visitor experience model [7]. Diverse factors, that define the general museum experience, can be identified from these works, such as the personal context of the visitor, the

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immediate experience and the remembered experience. While previous works considered only the user's dimension, King et al. [8] added another key element to consider when designing cultural visits: the relation between the subjective visitor's experience with the actions of the museum, gallery or heritage site in which it takes place. Thus, also the "environment response" has to be taken into account.

Considering the starting point provided by Falk and Dierking's work, Chang et al. [9] gave several guidelines when it comes to construct an experience involving visitors in a museum. Among these suggestions, it was affirmed that, without forgetting user's personal context, the museums experience should be designed in order to "*offer open and free choices and put learners in control of their own learning*". At the same time, it was emphasized that, to facilitate the learning process, all the activities should consider the social aspect of museums, encouraging social interactions with other visitors and museum staff. Moreover, it was suggested that museums educators should create opportunities to combine knowledge and information through devices and facilitators, as well as "*designing learning environments where visitors can navigate more spontaneously from one experience to the next"*.

All the aspects considered before about designing an effective UX seem suitable for the purposes of this study, being not only very compatible with the possibilities offered by VR technologies and metaverse platforms, but also aligned with the objective of connecting more than one museum subactivity to form a unified VME.

B. UX in VMs

For what it regards the topic of VMEs, the first thing to consider is certainly the VE where users are located. As sustained by Chung et al. [10], it is critical to consider the possibilities of creating unrealistic spaces that cannot be experienced in the real world, as well as making spaces to more faithfully resemble reality. Thus, the previous work focused on the possible influences that different VEs, realistic and unrealistic, can have on the overall UX. Findings demonstrated not only the influence of the VE on UX, but also that, while realistic representations provided the user with a familiar environment, unrealistic VEs stimulated their curiosity and aroused their interest in exploring the virtual space.

Another important aspect that has been explored in several investigations regards the stimulation of the user engagement and learning by a gamification of the overall experience. For example, Pietroszek et al. [11] designed in Unity a prototype for a virtual exhibit of the Museum of Peace Corps Experiences. The results of a pilot study showed positive feedback by the users in terms of engagement.

With the aim of defining a clear UX with the previous elements, it is considered fundamental to include the topic of IVAs, to guide users into the VME. A recent study by Trichopoulos et al. [12] declined the novelty brought by LLMs into a IVA for user's guidance inside a museum. The work included a solid architecture to build an IVA, including several features, such as Text-To-Speech (TTS), Speech-To-Text (STT) and GPT-4. In this case, the guide was also the content provider for the experience, since the LLM was directly pre-informed with several predefined responses regarding a certain topic. On the one hand, this aspect is not always considered favorable, since it only takes advantage of the Natural Language Processing (NLP) part of the LLM, without involving the generative AI aspect. This approach is generally preferred when using traditional chatbot frameworks (e.g. RASA, DialogFlow) that by nature rely on predefined responses and can grant a major control on the virtual experience. On the other hand, traditional chatbots are often limited by definition, as can be seen in several related studies [13] [14], and their development can possibly be relatively time consuming.

To the best of the authors' knowledge, besides comparative studies on performance [15] and answers correctness [16], there is currently no study that evaluate whether it is better to use LLMs or traditional chatbots as IVAs in the VME context. Thus, a comparative study is currently under development to show differences between the two approaches. By investigating the effectiveness and potential applications of LLM-powered chatbots in VR environments, along with a comparison with the traditional counterpart, it is believed that the UX aspect would be improved even more in VMEs.

III. VR Experiences

This study involved the creation of two different VR applications using Unity game engine for both of them: a metaverse experience, built for the Spatial platform using the provided software development kit (SDK), and a VW, that was built for the Meta Quest 2 and 3 Head-Mounted Displays (HMDs). The 3D assets to build both the VEs were created using Blender, whereas the 2D assets and textures were created using Adobe Illustrator and Substance 3D Painter. Finally, diverse tools were utilized in order to create the IVA, such as OpenAI API and diverse TTS/STT modules.

A. Meta-Museum experience

The metaverse experience, which can be enjoyed both from desktop or with a HMD, takes users on a virtual visit to an imaginary square, named "Piazza Memorabilia" (Fig. 1a), based on the Renaissance concept of the ideal city. The tour begins with a portrayal of the 3D reconstruction of an existing real-world room, located in Palazzo Madama (Turin, Italy), where the users meet Virgilio, an IVA whose purpose is to guide them through the VME. Then, a time machine lands in the room and the users can jump in to travel into the past, arriving in "Piazza Memorabilia". Once in the square, Virgilio assigns the task about finding and collecting five historical medals scattered around the square. At this point, the users are left free to discover the square and find the items previously mentioned. Once one of them is found, the historical character depicted on the medal appears as a 3D model with a spectral-looking shader and narrates its own story. The information is presented visually through a textual UI and vocally through the users' device audio system. Once all the medals are collected,

(a)

(b)

Fig. 1. Visual representation of the two VEs: (a) "Piazza Memorabilia" and (b) the VW

Fig. 2. Real world medal (A), and custom user-created medal (B)

the users are encouraged to continue the VME by visiting the renaissance VW. The VE also include a virtual showroom, in which historical medals created by the users during the VW will be exhibited.

B. Virtual learning workshop experience

In the VW experience (Fig. 1b), the users create their own customized historical medal using Oculus VR Toolkit features for hands tracking. They can always switch to controllers if preferred. The application presents a menu for choosing between a tutorial scene or directly entering the VW experience.

In the tutorial, the users learn basic interactions, including teleportation, grabbing objects, and pressing UI buttons. The specific gestures are presented through UI panels and representative 3D models. However, the users can also ask for advice vocally from the IVA if the integrated instructions are not sufficient.

The VW is characterized by four working spots:

- Customizing the medal;
- Creating a mold with a wax model;
- Selecting and melting metal to cast the medal;
- Refining the medal.

Each spot is timed, and if the users take too long, actions are automatically performed via animation to assist them and maintain the experience's duration.

IV. UX Formal Elements

A. Virtual Environment

The UX that seamlessly guides the users from the metaverse to the laboratory is characterized by various formal and interactional elements.

Firstly, the space that connects the two experiences is unified by semantic traits and a consistent graphics style. The entire experience immerses the users in a historical and educational journey: initially, an idealized Renaissance square becomes the stage for exploring and understanding the medals, elevating and contextualizing them in their respective periods. The journey in the metaverse ends at the entrance of what in reality is the VE of the VW. This is considered fundamental, since it represents not only a practical gateway to the VW experience, still within the same settings, but also an important narration connector.

The idealized Renaissance VE avoids giving a precise historical-geographical connotation to the historical medals, which come from various geographical areas, while simultaneously allowing the users to learn architectural notions of the time. Furthermore, consistently with the analysis of state of the art, both the VR applications are designed with a cartoon-style graphics to stimulate the users' curiosity and engage them gently in a familiar environment.

B. Virtual Avatar Guide

The design of the virtual owl character, Virgilio, incorporates modules for seamless user interaction via voice commands. During the experience, the IVA will be in charge of two main tasks: providing advice in terms of gameplay mechanics (e.g. teleporting and grabbing) and instruct the users about all the cultural contents of the VME. The users can trigger the interaction with the IVA by pronouncing a "magic word" (calling it by its name) and ask a question about the current task faced by prompting the LLM system.

As illustrated in Fig. 3, the current system architecture relies on four primary components. Initially, AI-based modules (Whisper open source model) handle speech recognition and conversion to text, ensuring precise interpretation of user input. The text is then added to a buffer, that contains the

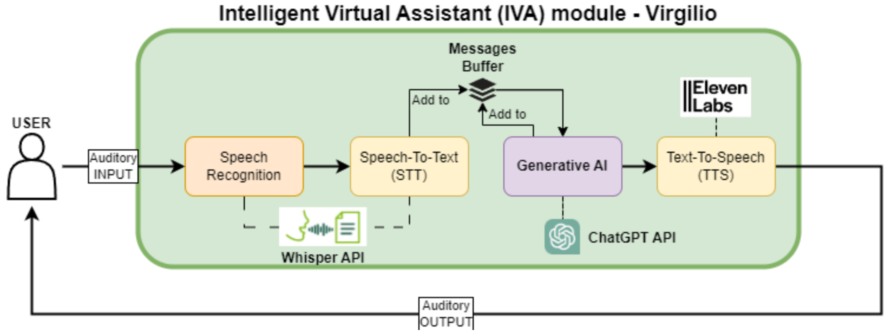

Fig. 3. Schematic representation of the IVA architecture;

history of the conversation. Following this, the entire buffer is passed to a Generative AI module, powered by the OpenAI API for Unity, enabling Virgilio to generate coherent responses to users' queries. The response generation relies on the feature named AssistantAPI, that permits to create a customized LLM assistant. This was achieved by following the prompt engineering guidelines provided by OpenAI [17]. Finally, the architecture integrates the ElevenLabs API for enhanced TTS quality. This design facilitates immersive and responsive interactions between the users and the virtual owl, providing contextually appropriate responses throughout the VR experience.

V. Conclusions and Future Developments

In this work it was reported a first investigation to build an effective UX in the field of VMEs. More specifically, two applications were presented: "Piazza Memorabilia" and a VW, still under an improvement phase. In order to connect the experiences, two key features were considered to build an optimal UX: VE and IVA. The first aspect was implemented with cartoon-like graphics to stimulate users' curiosity in exploring the VE. The IVA was declined in a LLM system, to make it be able to provide support and cultural contents to the users along all the experience in a innovative way. Future developments will include the testing of the system with users, for which a suitable demographic target currently under evaluation could possibly be high school students. Finally, a further comparative study will be performed on which technology (traditional or LLM chatbots) is more suitable to build an IVA in VMEs, possibly considering multiple LLMs.

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