A Location-Based VR Museum

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***Abstract*—This poster presents a novel type of Virtual Reality (VR) application for education and culture: a location-based VR Museum, which is a large-room scale multi-user multi-zone virtual museum. This VR museum was designed to support over 100 simultaneous users, walking in a large tracking system (600 m^2) and sharing a ten times bigger virtual space (7000 m^2) containing indoor and outdoor dinosaur exhibitions. This poster is giving an overview of the system and its main features as well as discussing its potential benefits and future evaluation.**

***Index Terms*—VR Education, Large Tracking System, Avatar**

I. Introduction

In recent years, digital technology has changed the ways museums document, preserve and present cultural heritage [1]. Museums are frequently modernizing their exhibitions with digital experiences, for instance including Virtual Reality or Augmented Reality applications [2]. Digital games in museums are one way to socially involve large groups of students in learning complex material collaboratively [3].

In this paper, we are presenting a first prototype of what could be seen as the next generation of a museum: a location-based VR Museum, which is purely based on virtual knowledge exhibited in a large shared physical space. The current version of the system could be used as an experimental platform to study the benefits, limitations and challenges of a *fully* VR museum, where visitors are actually walking and sharing the same physical space while *everything else* is virtual (Figure 1). One of an important objective is to preserve the social aspect of the real „museum experience“ involving *visiting* exhibitions in groups, family or friends. We also want to augment this experience by increasing the enjoyment and learning outcomes by replacing their content with interactive and immersive simulations.

As discussed in [1], the main advantages of a *fully* VR museum would be i) to solve issues of space limitation for new exhibitions, ii) to considerably reduce the exhibitions cost and installation time (i.e., fast inclusion of new exhibitions and virtual rooms), iii) to solve curators concerns regarding the fragility of museum artifacts, iv) to foster social engagement and collaboration with multi-user interactive exhibitions [3], v) to enable experiences and interactions with extinct species, destroyed cities or historical sites, vi) to produce a new museum experience based on ages, cultures, preferences (e.g., better view for kids or person with impairments or disabilities), vii) to provide a platform for new types of exhibitions, for instance, engaging one or many visitors in interactive storytelling exhibits and viii) to preserve social aspects (meeting, visiting and learning in groups). Due to the lack of large-scale tracking systems, the feasibility as well as the potential benefits or limitations (e.g., health and safety issues, user acceptance or learning outcomes) of such VR museums, have never been completely investigated yet. Consequently, our first research step focused on designing and programming a VR system capable of supporting the requirements of such a VR museum. The rest of this paper presents our solution and future work.

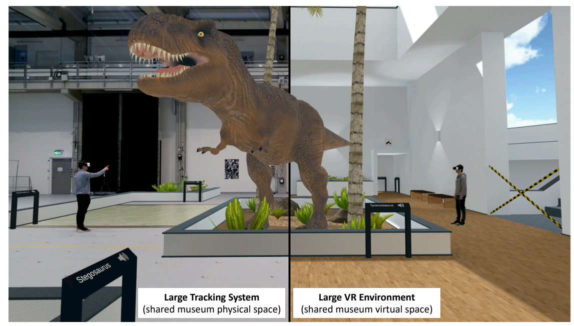

Figure 1. Location-based VR Museum Overview

II. System

The simulation was implemented in Unity 3D using a client-server network architecture. Video information was displayed by Samsung Galaxy S7 and S8 smartphones in combination with the Samsung GearVR HMD. Audio information was provided by a Beyerdynamic DT-1 one-ear headphone. The system is capable of handling a high number of users (Up to 100) with the use of a large-scale tracking system (Up to 600 m^2). It is a large-scale radio frequency-based real-time location system (RTLS) operating in the Gigahertz band [4] which covers a tracked area of approximately 30m x 20m (Figure 2-H). A Radio Marker ID is fixed on each GearVR to track visitor's head position. The system performance is optimized for a comfortable VR experience using a custom occlusion culling system as well as MobileVR-optimized 3D Scene & Models, that results in 50 - 60 FPS on average.

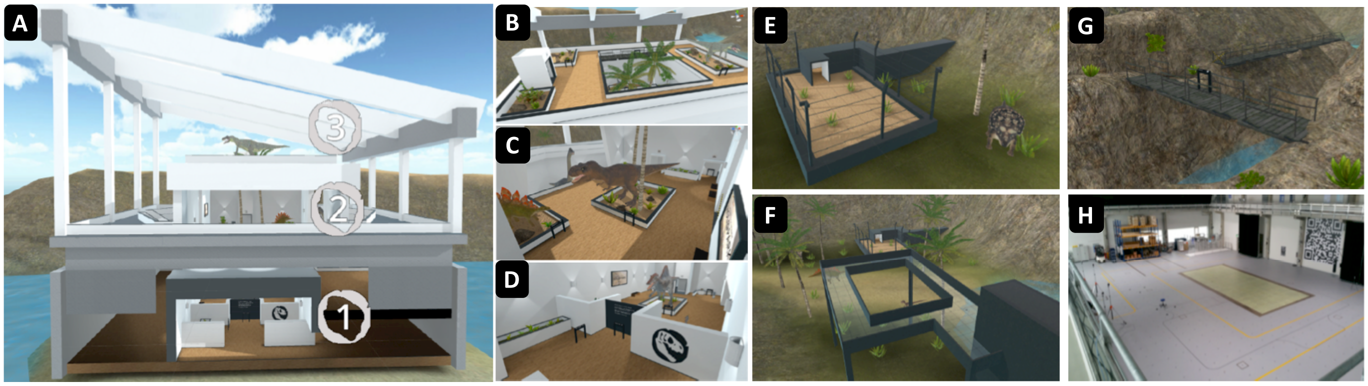

Figure 2. Museum's Zones Overview - A) The Three-Floor Main Museum Building, B) Third Floor, C) Second Floor, D) First Floor, E) Outside Park with live dinosaurs, F) Outside Terrace, G) Outside Pit with live flying dinosaurs and H) The Large Tracking Zone (One floor - 32m by 20m)

As depicted in figure 2, the virtual environment consists of a museum and a dinosaur park with six virtual zones in total (3 Inside and 3 Outside). The indoor museum consists of 3 floors with 1800 m^2 and 11 exhibitions. The outside part is a park of 5000 m^2 with 3 exhibitions showing live dinosaurs.

The following features were implemented:

1) *Interactive Exhibitions*: Visitors can activate audio and visual descriptions by looking at the information board for few seconds (gaze-based activation).
2) *Zone Traveling*: Visitors can access exhibitions on different floors or outside through *teleportation* represented by elevators activated via gaze-based activation.
3) *Way Finding*: Visitors can see an interactive mini-map of the environment and can teleport to any place in the museum or outside [5]. A 3D world-in-miniature, with a *you-are-here* marker is efficient to specify a target location and build spatial understanding [6].
4) *Multi-zone Synchronized Visitor Avatars:* Visitors can see their virtual body (i.e., simple blue pillar) as well as seeing other visitors' avatars (Figure 3). We use a similar technique to the *shadow-avatar* [7] to prevent visitors collision when evolving in a different exhibition (e.g., on different floors in the virtual museum). The visitors with transparent avatars (i.e., like a *ghost*) are indicating their physical proximity while being in a different part of the virtual environment (e.g., on a different floor).
5) *Guide Control Interface*: Staff can watch visitors and assist them via virtual camera systems (Figure 3).

Figure 3. The *Museum Guide Control Interface* - with multiple camera selections (including visitor's perspective) and the *Multi-zone Synchronized Visitor Avatars Representation* - solid: same virtual space, transparent: different virtual zones (e.g., visiting other exhibitions on a different floor/park)

III. Conclusion

This paper presented a location-based VR museum using a large-scale radio tracking system, which was already tested with 5 simultaneous participants. We demonstrated its technological feasibility and discussed its specific features and expected benefits. However, only empirical studies could now answer the most important question: *Can a location-based VR museum improve visitor's engagement, enjoyment and learning outcomes?* Our future work also includes the integration of social behavior augmentation techniques to increase social presence and engagement as suggested in [8].

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